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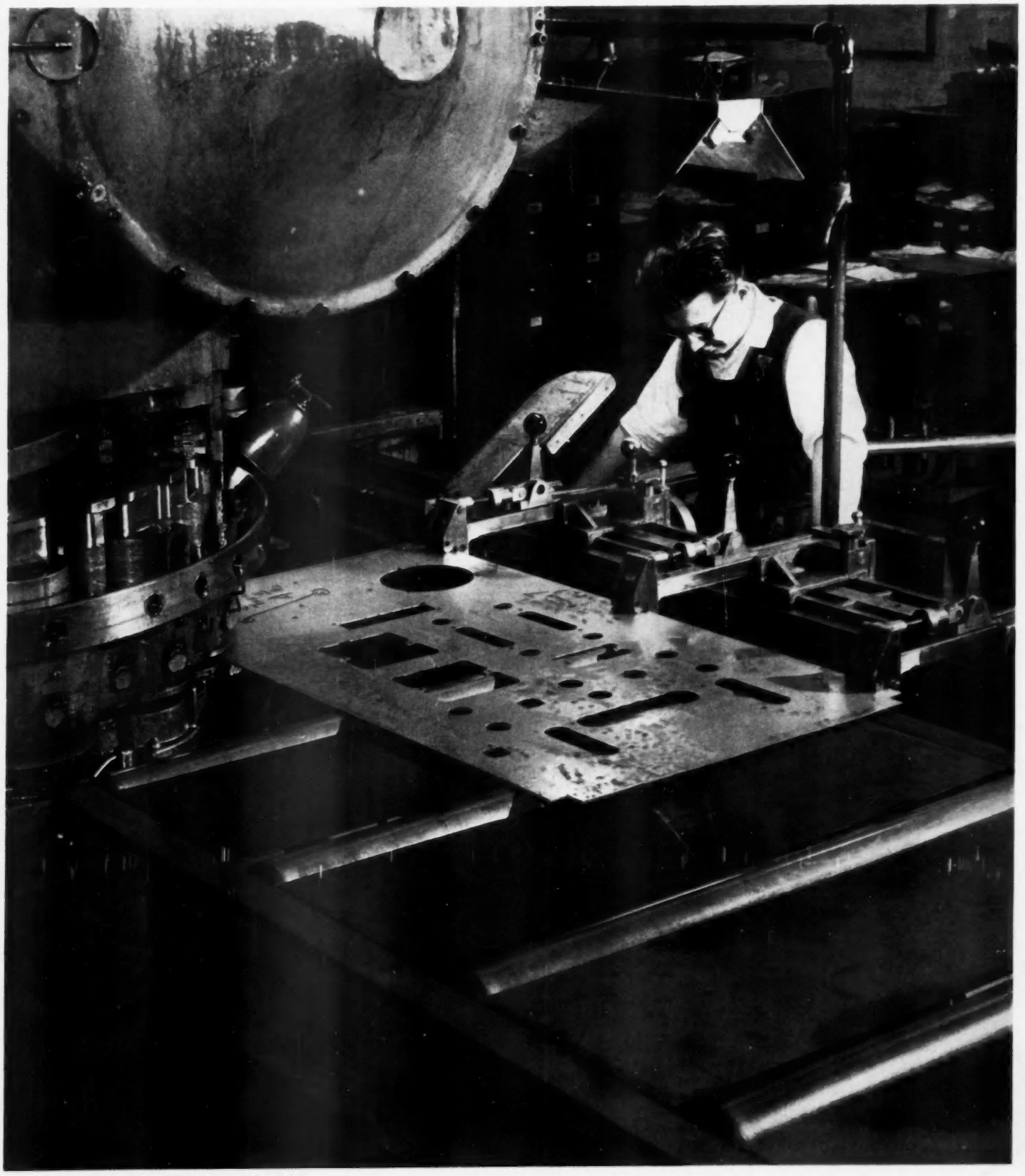

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GERMAN RECIPE

AT this time of year the aircraft industry has come to expect a dose of criticism from some speaker at the annual conference on problems of aircraft production which is organised by the Institution of Production Engineers. This year the criticism came from an overseas speaker, Herr Karl Frydag, a director of Henschel und Sohn, who in his Lord Sempill lecture discussed "Concentration of Aircraft Development."

Like Sir Roy Fedden and Mr. W. E. W. Petter at earlier conferences, Herr Frydag considers that the British aircraft industry are trying to cover too wide a field. No single European country, he suggests, can hope to compete with North America unless it concentrates on a limited number of projects. "Comprehensive long-term planning based on a complete careful analysis of all contemplated development" and "strict adherence to the selected projects and their developments to the utmost of their possibilities" are his ingredients for success, and it was these factors, apparently, which led to the substantial productivity of the German aircraft industry at the beginning of the war. When, in 1942, the German military leaders began to get rattled, and started interfering with armament programmes, substituting improvisation for planning, production fell dramatically. In March, 1944, when monthly output had fallen to 2,000 aircraft per month, the authorities reverted to the policy of concentrating production efforts and by September of that year output had increased to 4,800 per month, in spite of heavy bombing raids.

Although some of his listeners may have recalled that the Battle of Britain was won by "the few" in 1940, and may therefore feel that detailed planning and concentrated production are not the whole secret of success, the British aircraft industry and the Government might learn something from German methods. "For development and research," Herr Frydag said, "several test plants were erected and provided with first-class equipment covering all kinds of wind tunnels including supersonic. For the engine manufacturing industry, a full-scale altitude engine test plant was created which was ultra-modern for that time. Research and development of airframes were concentrated in the works of seven firms. The development of . . . engines was concentrated in three aero-engine factories. All firms had to use the same drawing system and the same standards. The factories of the accessory industry as well of the light metal and steel industries were also planned in the above-mentioned programme."

An important point brought out by Herr Frydag is that a healthy aircraft industry is a necessity for any modern industrial country, because aeronautical research fertilises every industry, from radio equipment and machine tools to bridge-building. His recommendations for a virile aircraft industry are joint control by the Government and the industry, working together to decide which new projects should be carried out and how the production contracts should be distributed to make the most economical use of research and development facilities and avoid parallel developments. Most engineers will agree with him that more emphasis should be placed on the importance and training of production engineers, but there may not be universal approval for his suggestion of uniting smaller firms into "powerful and efficient units," though it is difficult to see how such firms can, individually, provide all the technical resources required to build a modern aeroplane.

The idea of concentration crops up in many contexts in addition to the aircraft industry. Famous soldiers are fond of advocating it, and all leaders concerned with obtaining the maximum results from given resources are attracted by the streamlining effect of concentration. At one time, success in business was said to go to the man who adopted such a policy, but since the war there has been an opposing tendency. Diversification of products in a firm or group has been considered better than putting too many eggs in one basket. The basic principle, surely, is that when plans for the future can be clearly foreseen, and especially when the effect of outside influences can be forecast with reasonable accuracy, it is wise to go for the maximum concentration, but when the future is obscured by many intangibles it is better to allow a number of different approaches. It is this sort of situation in which the aircraft industry is bound to operate. The developments that are likely to take place in the technical field alone are so diverse and unpredictable that it would be folly to put a strait-jacket on the industry and condemn the brains in that industry to work to rigid terms of reference. The difficulty arises, of course, from the fact that aircraft firms are financed, with few exceptions, by the State. The Government departments concerned with the industry are therefore judge and jury, doctor and hangman, to the firms comprising the industry. This delicate position has, in practice, led the Civil Servants to be unwilling to do anything which would either finish off or give an unfair advantage to individual companies. The ordinary rough and tumble of business is side-tracked; the favours of Government finance are embraced. The industry has some great achievements to

its credit and some modifications to the system are almost certainly needed, but they will require much deeper study than appears to have been given them so far.

* * *

Plain Words

The structure of Government should reflect the requirements of the time; even more, since it is the organ of leadership, it should be one step ahead. Since a fundamental feature of our own times is the demand for electric power, few will not applaud the appointment of Sir Percy Mills as Minister of Power in Mr. Macmillan's new Cabinet. Hitherto, it has seemed anomalous that an industrial society can be led by men with no knowledge of industry, but the choice of Sir Percy, who has wide industrial and engineering experience, goes some way to remedying this deficiency. That his new post should carry Cabinet responsibility is an added mark in favour of the decision. But is it not also an indication that the structure of British Cabinets is out of date?

Sir Percy's appointment is an example of the *ad hoc* procedure which is traditionally a feature of British constitutional evolution. But can such an approach keep pace with the rapid changes which are taking place to-day? A Minister whose brief is so diffuse as to include atomic power and iron and steel, and whose effectiveness must depend on the rapid establishment of a smoothly working department, may find his efforts frustrated by the powerful demands of his politically more experienced Cabinet colleagues. How, then, can the requirements of a rapidly changing society be met by a democratic Government? A new philosophy of Cabinet structure is needed.

The threads of Government may be traced far back into the past. Kings held control of the State's military power long before Alfred the Great; Henry VII, through the Court of Star Chamber, established a central legal organ; Charles I, requiring funds, introduced the concept of Ship Money, and founded the State's financial power. These threads continue a great tradition, but they also tend to hold us back, to keep us from making the progress that other later constitutions seem to facilitate.

There are several possible approaches to the planning of a Cabinet. They may be abstractions, as in the Soviet Union, where ministers of the Presidium are responsible for long-term planning and short-term planning; or functional responsibilities like fuel and power and agriculture; or the economic factors—capital, resources and labour. Whatever direction we take, it is clear that a full study of the subject is required, bearing in mind the necessity for "built-in change," which is so characteristic of the times. The Prime Minister has recognised this need in creating a Minister of Power, but no prime minister can at short notice conceive a Cabinet structure designed ideally for the job. Sir Percy Mills is the right man for the job, but is the job right?

INTRODUCING EXPLOSIVES

Although explosives are known to be a useful tool in many fields of engineering, their supposedly hazardous character may to some extent have prejudiced their wider use. To-day, however, they are an instrument of some precision, and in the hands of the specialist are both safe and versatile. Given a more widespread knowledge of their properties and limitations, their application might be extended still further, and it is the aim of this article to draw attention to their scope. Reference is made to a number of special techniques employing explosives and to certain items of equipment associated with their use. In addition, we discuss various methods that have been adopted for testing these materials. The information on which the article is based has been supplied by the Nobel Division of Imperial Chemical Industries, Limited, Millbank, London, S.W.1, and a section dealing with pulsed infusion shotfiring has been taken from an account by Mr. R. Haslam recently published in the I.C.I. Magazine. *The manufacture of nitroglycerine, which forms the basis of many modern explosives, was described in* ENGINEERING *on July 20, 1956, page 73. In the present article we begin by summarising those sections of the previous article dealing with the properties of nitroglycerine and its manufacture and history.*

Origins

Explosives have been known since early times and gunpowder is said to have been discovered by the Chinese. Nitroglycerine was first made by Ascanio Sobrero of Turin University in 1845, and two years later he described the properties of pyroglycerine, as he called it, before the Academy of Sciences in Turin. The first small plant for its commercial manufacture was erected at Heleneborg, near Stockholm, where production began in 1862. Mixed sulphuric and nitric acids were placed in open earthenware jugs and glycerine was added slowly with hand stirring. The mixture was allowed to cool after each addition of glycerine, since no means were provided to remove the heat of reaction. Since that time a number of refinements have been added, such as production in larger and larger batches, the introduction of the Schmid process, in which nitration is continuous, and most recently the development of the Biazzi system, which is continuous in operation with numerous safeguards, including remote control.

The prospectus issued by Alfred Nobel and Company, of Hamburg, in February, 1866, regarding the virtues of "blasting oil" is of great historical interest in the evolution of the science of blasting, because it clearly set forth its advantages over black-powder—advantages which were even then properly recognised, and also certain defects which only time and development could eliminate. In contrast to black-powder which could be initiated with a flame or spark, nitroglycerine was difficult to detonate at will. Nobel overcame this difficulty by the invention of the mercury fulminate cap, the ancestor of the modern detonator, which was first mentioned in his patents dated 1864.

Explosive Products

Many serious accidents occurred while nitroglycerine was being transported or used as a blasting agent, and the inventor experimented to find a satisfactory absorbent substance. After patient work he found that 25 parts of kieselguhr, a diatomaceous siliceous earth, would absorb 75 parts of nitroglycerine to form a paste which did not exude. Nobel called this dynamite. It was found that dynamite could be packed in cartridges, which were suitable for charging shot holes. The discovery of the percussion cap and dynamite ensured the success of the new industry and allowed Nobel to devote his energies to forming new companies and building more factories. Between 1866 and 1873 fourteen factories were started in Europe and America. The Ardeer factory of Imperial Chemical Industries, Limited, was started in 1871, and the first nitroglycerine was made on January 13, 1873. Nobel subsequently took out patents for blasting gelatine (93 per cent. nitroglycerine, 7 per cent. nitrocellulose), a whole range of ammon-gelatine-dynamites and ballistite, a powerful propellent powder.

From the wide range of explosives available commercially to-day a suitable type can be selected for every blasting operation. Explosives are extensively used in a variety of industries, for winning coal and metalliferous ores, for sinking new shafts, for quarrying, for driving tunnels, for demolitions, for excavation work and, of particular importance at the present time, for the seismic method of oil prospecting.

Properties

Nitroglycerine is the tri-nitric ester of glycerol and has the formula:

$$\begin{array}{l} CH_2O\text{---}NO_2 \\ | \\ CHO\text{---}NO_2 \\ | \\ CH_2O\text{---}NO_2 \end{array}$$

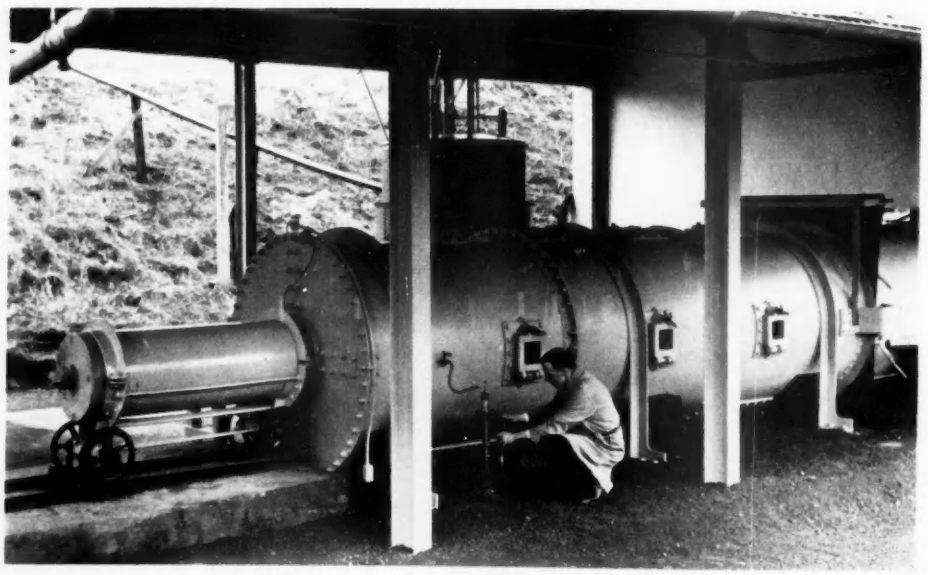

Fig. 1 In certain mines, where considerable gas or coal dust is present, only a "permitted" explosive may be used. For the gallery test, an explosive is inserted in a chamber, such as that shown, and ignited in an atmosphere of air and methane. A "non-permitted" explosive will detonate the gas mixture.

Its molecular weight is 227·09, specific gravity 1·596 at 20 deg. C., and solubility in water 0·18 per cent. at 20 deg. C. It has melting points at 13·2 deg. C. in the stabile form and 2·2 deg. C. in the labile form. It decomposes on detonation according to the formula:

$$4(C_3H_5N_3O_9) \rightarrow 12CO_2 + 10H_2 + 6N_2 + O_2$$

with a detonation velocity of 2,000 metres per second, or 8,000 metres per second according to conditions. The temperature of explosion is 3,400 deg. C. and the explosion pressure 9,200 kg. per sq. cm. (131,000 lb. per sq. in.). As a measure of its sensitivity, it can be detonated on a steel plate by dropping a 2 kg. weight on it from a height of 2 in.

Testing

Gallery Test.—The National Coal Board is the largest single user of explosives in the United

Fig. 2 The power of an explosive may be tested in a ballistic mortar. The charge is placed in the mortar, which is suspended like a pendulum, and the angle through which the mortar swings is a measure of the explosive force.

Kingdom. Explosives for use in coal mines are submitted to the Safety in Mines Research Establishment at Buxton for investigation, where they are tested in a gallery similar to that illustrated in Fig. 1. The gallery shown is at Ardeer and is an exact replica of the Buxton gallery. The Coal Mines (Explosives) Order, 1951, provides that in certain mines, where considerable

TABLE I.—*Types of Permitted Explosives Specified by the National Coal Board*

Type	Manufacturer			
	Imperial Chemical Industries Limited	Cooke's Explosives Limited	The Colliery Explosives Company, Limited	Explosives and Chemical Products Limited
Eq. S Explosives	Unigex Unifrax or Unifrax H Unirend Unigel	Lesslak Rensol Equinox Pentregel	Compex No. 2 Compex No. 1 Trinite No. 1 Trinite W	Danespex Minespex Colespex Lodespex
Sheathed explosives	Polar Ajax Polar Viking	Anti-frost Nitrox No. 2 Anti-frost Penrhyn Powder No. 2	X.L. Hawkite Simex No. 3	Driftex Minex
Unsheathed explosives	Polar Ajax	Anti-frost Nitrox No. 2	Simex No. 3	Driftex
Explosives for firing under water	Hydrobel	Infugel		

NOTE.—Unifrax and Unifrax H have the same composition; the suffix H denotes manufacture at Haswell.

TABLE II.—*Diameter and Size of Cartridges as Specified by N.C.B.*

Type	Diameter, in.	Size, oz.
Eq.S	1¼	Unifrax or Unifrax H, Lesslak, Trinite W and Trinite No. 1 2, 3, 4, 6
	1 7/8	3, 4, 6
	1¼	Other Eq.S 3, 4, 6
	1 7/8	3, 4, 6
Sheathed	1¼	Polar Ajax, Anti-frost Nitrox No. 2 and Driftex 2, 3, 4, 6
	1 7/8	Polar Ajax, Anti-frost Nitrox No. 2, X.L. Hawkite and Driftex 3, 4, 6, 8
	1¼	Polar Viking, Anti-frost Penrhyn Powder No. 2, Simex No. 3 and Minex 2, 3, 4, 6
	1 7/8	3, 4, 6
Unsheathed	1¼	Polar Ajax, Anti-frost Nitrox No. 2, Simex No. 3 and Driftex 4, 6, 8
	1 7/8	4, 6, 8
Explosives for firing under water	1¼	Hydrobel and Infugel 6, 8
	1 7/8	12, 16

gas or coal dust is present, no explosive shall be used other than a " permitted explosive," that is an explosive permitted by the Ministry of Fuel and Power for the purpose of the order. The official check is divided into various sections but the most important is the gallery test. Types of permitted explosives for use by the National Coal Board are given in Tables I and II, which appear in a revised N.C.B. specification published recently (No. P.112/1957). The gallery is filled with a firedamp/air mixture (9 per cent. methane in air) and the shot inserted in the cannon borehole at one end (on the left in the illustration). On firing, a " non-permitted " explosive, such as those used in quarrying, will give rise to explosion of the mixture, whereas a " permitted " explosive will not ignite the gas. The official test requires that five 8 oz. unstemmed charges and five 28 oz. charges with a 1 in. clay plug stemming shall be fired into the firedamp atmosphere, and five 28 oz. charges into the gallery well strewn with fine coal dust, without producing an ignition. The test is accepted by the authorities in Britain, Australia, South Africa and Canada as definining explosives suitable for coal-mining and is said to be more stringent than the corresponding United States test.

Power Test.—The " power " or " strength " of an explosive is effectively a measure of the work it can do in blasting, and may be defined as the maximum mechanical work which the explosion products are capable of performing when utilised most efficiently in a given expansion system. An apparatus used for measuring the power of an explosive is the ballistic mortar, an example of which may be seen in Fig. 2. Power is conveniently and precisely measured by using the explosion to expel a " shot " from the mortar and recording the recoil of the latter, which is suspended so as to swing like a pendulum. The theory of the mortar is basically that of an internal combustion engine or of a military propelling piece, with the simplifying provision that in the ballistic mortar, because of the high velocity of detonation of the explosive, the whole of the explosive is converted into its decomposition products before any appreciable work has been performed. The ballistic mortar, weighing 1,025 lb., is suspended as a pendulum on delicate knife edges. Ten grams of an explosive are fired in a recessed chamber towards the back of the mortar and the released decomposition products propel a standard weight, of 36·5 lb., into a non-abrasive trapping medium. No measurement is made on the projectile but the angle of recoil of the mortar is noted. First, the angle of recoil, A_o, is recorded for polar blasting gelatine, which serves as a standard and is the most powerful commercial explosive; then the angle of recoil, A, is also measured for the explosive of unknown power. The power, P, of the explosive of unknown power is given as a percentage of that of polar blasting gelatine according to the equation,

$$P = 100\left(\frac{1 - \cos A}{1 - \cos A_o}\right).$$

The ballistic mortar is a precision instrument which, with careful handling, can be used for 10,000 to 20,000 shots before the mortar itself is sent for relining.

Velocity of Detonation.—In addition to power, the capacity of an explosive for doing work is given by its velocity of detonation (V.O.D.). It is thus desirable that this quantity should be known precisely, since, together with power, it determines the type of duty for which a given explosive may best be used. In the detonation of a cartridge a narrow zone of intensely high temperature and pressure called the " detonation wave " travels at enormous speed along the cartridge. The chemical reactions in, and just behind, the zone are the origin of the blasting

Fig. 3 The velocity of detonation or the rate at which the detonation wave travels through an explosive charge may be measured by the Dautriche method.

effect. The rate at which these reactions occur is obviously a fundamental property of the explosive and it is thus important to measure accurately the velocity of the detonation wave. One approach is the so-called " Dautriche " method, which makes use of the standard detonating fuse, Cordtex. It is necessary to know the V.O.D. of the Cordtex, so that short time intervals of the order of a few microseconds can be measured.

The Dautriche method is based on the fact that when two detonation waves meet, there is an enhanced mechanical disturbance. In applying the method it is arranged that the ends of a uniformly propagating length of Cordtex, part of which is mounted on a lead bar, are inserted at different selected points along the length of a column of explosive the V.O.D. of which is being determined. The detonation wave in this explosive initiates in turn each end of the Cordtex. A mark is produced on the lead bar where the detonation waves from the two ends of the Cordtex meet. By measuring the distance between this mark and the centre point of the Cordtex and then making a simple calculation, the V.O.D. of the explosive is obtained. The arrangement of the cartridge, Cordtex and lead bar is indicated in Fig. 3.

Lead Plate Test.—The effect of detonation velocity on the explosive properties, and in particular on the penetrating power of an explosive, is clearly illustrated by a test in which cartridges are fired in contact with thick lead plates. If, for example, two cartridges of similar weight, shape and composition are fired, one cartridge being initiated to high velocity and the second to low velocity, it will be seen that the

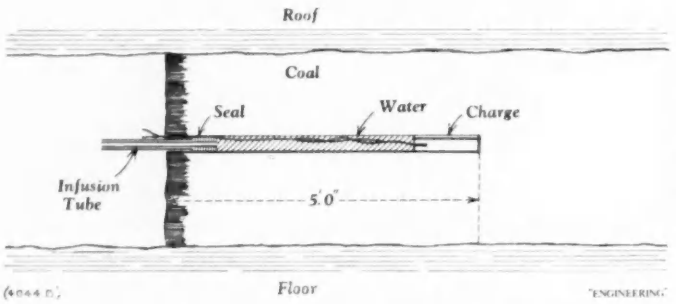

Fig. 4 In the technique for blasting coal known as pulsed infusion shotfiring, developed by the Nobel Division of I.C.I., water is used to spread the force of the explosion through the seam, and to eliminate the risk of firedamp explosion.

cartridge propagating at high velocity will do more robust work than the other.

Detonators

As has already been observed, nitroglycerine is difficult to initiate at will, and to do so it is necessary to use detonators. Reference has been made to the mercury fulminate cap invented by Nobel for this purpose, but to-day electric detonators are normally employed. By closing a switch on the " exploder " an electric current is made to flow in a circuit passing through the detonator, so causing a fine wire to become hot; this in turn ignites a surrounding fusehead, thereby initiating the main charge in the detonator and causing it to explode.

It is possible to introduce delay elements, which burn at a controlled rate, between the fusehead and the main charge, so that a definite interval occurs between the passage of the current and the explosion of the detonator. By suitable choice of the nature and length of the composition used in the delay element, the time interval can be precisely controlled to give any desired delay. For example, the delay period of the short-delay detonator is one-fortieth of a second (25 milliseconds), while delays of half a second can also be achieved.

As the application of explosives to many surface and underground operations became better understood, it grew increasingly evident that the firing of multiple shots in a definite time sequence resulted in more efficient blasting. it has been found possible to arrange delay detonators in series, so that they explode at known time periods. This is achieved by adjusting the lengths of the delay elements, so that if the fuseheads of the detonators of a delay series are initiated simultaneously, then the length of delay element will determine the time at which each particular detonator will explode. Delay detonators have a wide application in quarrying, tunnelling and metalliferous mining and at present they are finding their way more and more into coal mining.

Pulsed Infusion Shotfiring

A new technique for winning coal—called pulsed infusion shotfiring—has recently been developed by the Nobel Division of I.C.I. Water is used to spread the force of the explosion more effectively through the coal seam, and at the same time to eliminate risk of firedamp explosion.

Water has long been regarded by coal miners as one of their natural enemies. In the past a sudden inrush of water into mine workings has been responsible for a number of big disasters. To-day water is being increasingly harnessed as the ally of the miner. It is used to suppress dust in the fight against the lung disease pneumoconiosis. It is used, too, hydraulically to propel coal from the workings to the surface, thus eliminating the complexities of haulage and winding of coal by conventional methods. Recently a new use for water in the mines has been developed. This is to combine water and explosives together in the winning of coal, and so to lay the dust and fumes of shotfiring and to eliminate any possibility of an ignition. Thus the use of explosives together with water as a stemming or sheathing agent has long been the subject of research and experiment, and in August, 1952, the Safety in Mines Research Establishment suggested a discussion with Nobel Division on this matter. Since then Nobel Division has been responsible for the development of the new technique, known as pulsed infusion shotfiring.

The technique, which is illustrated in Fig. 4, consists essentially of firing an explosive charge in a borehole filled with water under pressure. The water is introduced through an infusion tube which also seals the hole. Subsequently when the charge is fired it produces a high-pressure impulse in the water, which is transmitted into the numerous cleavage planes and slips, and thus breaks the coal. First a hole is bored into the coal and an explosive charge inserted. Then an infusion tube is pushed into the collar of the hole. This device consists essentially of a tube and a gland. It performs a dual function: it introduces the supply of high-pressure water into the hole and also acts as a sealing plug. Pressures of up to 1,000 lb. per sq. in. are employed, but more typical figures range from 300 to 400 lb. per sq. in. The water then penetrates into the surrounding coal, filling up any slips or breaks. Under this pressure a shot is fired with a submarine detonator, and the impulse of the explosion is transmitted throughout the water mass, thus breaking down the coal. It is found that with this technique the explosive energy available is used far more efficiently than in blasting in the conventional manner " in the dry," and in addition the quality of coal breakage is better. Pulsed infusion shotfiring has one further advantage. It tends to " pre-soften " the coal, and this may make it possible to extend to the harder seams the use of cutter loaders. These machines both win and load by mechanical means and have hitherto been found to be effective only with soft, friable coal.

A special permitted explosive had to be developed to meet the demands of this technique and has been named " Hydrobel." Its composition is such that it will work reliably under the high hydrostatic pressures involved. For example, tests have shown that it will fire effectively after being subjected to a pressure of 1,000 lb. per sq. in. for 24 hours. Previously, the best waterproof permitted explosives available would withstand a pressure of only some 20 lb. per sq. in.

This new method of blasting is now in regular use at some 35 collieries, and well over 200,000 shots have been fired in this manner. National Coal Board officials and inspectors of mines have expressed enthusiasm for the new technique, which is generally felt to have considerable potentialities. Interest in pulsed infusion shotfiring is now being shown in a number of other countries. Mining engineers from France, Holland, Australia, India, the United States and Canada have already visited this country to see the new technique in operation.

Alternatives to Explosives

Almost all the coal produced in this country is obtained by means of permitted blasting explosives, but despite the high degree of safety attending the use of modern explosives in coal mines, even safer methods are sought, and the use of special devices is increasing. One such device is known as " Hydrox," which, though not strictly employing explosives, performs a similar function. It comprises a steel tube containing a solid gas-producing composition. Gas is generated within the tube until the pressure is sufficient to blast coal, when it is suddenly released by the bursting or shearing of a disc. The gas is chemically inert, and is too cool to ignite firedamp or coal dust. The device is thus inherently safer than permitted explosives and it is officially recognised that shot firing with Hydrox can be permitted in conditions where regulations forbid the use of explosives.

The device has undergone several changes since it was first introduced in 1933, and the most recent development, which is now being subjected to extensive testing in the field, possesses many advantages over the earlier Hydrox. The greatest advantage is that it can be loaded at the working face by hand, so that

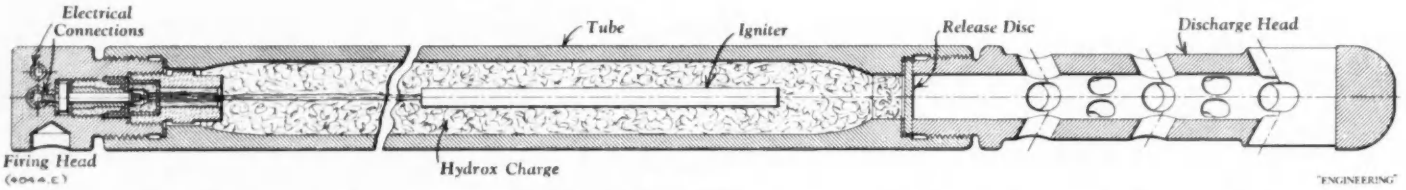

Fig. 5 An early form of Hydrox device, comprising a steel tube which contains a gas-producing composition: with its aid blasting can be effected safely and without explosives. When the pressure in the tube has built up sufficiently for blasting, the gas is released by shearing of a disc.

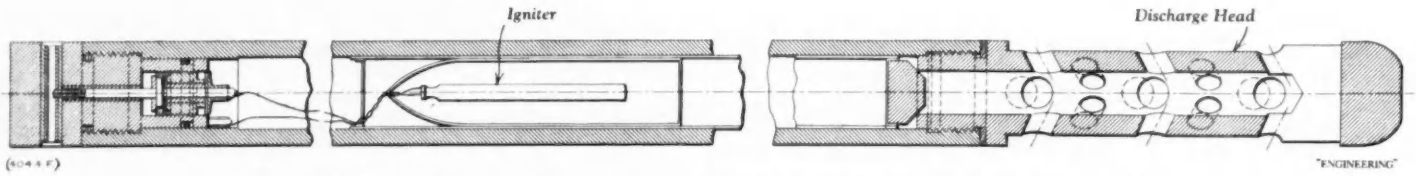

Fig. 6 New form of Hydrox which can be re-charged at the coal face by hand, using a special cartridge.

transport of the heavy tube to and from the workings is unnecessary.

This major advantage is made possible by the design of a unit cartridge with special properties. The main charge, while incapable of reaction under atmospheric pressure, nevertheless produces gases (a mixture of nitrogen, water vapour and carbon dioxide), which build up pressures of 12 tons per sq. in. under the confining influence of the steel tube, when initiated by a primer composition supplying the necessary heat and initial pressure for the reaction. All the components, both separately and collectively, are perfectly safe in even the most dangerous atmospheres of mine gas. The earlier Hydrox assembly is illustrated in Fig. 5 and the new version in Fig. 6.

The use of steel-tube devices is at present limited, but is slowly increasing, as is the applisation of blasting techniques generally. A widespread knowledge of explosives and their properties may lead to the discovery of further applications. Indeed, it might be borne in mind that the use of explosives is not limited to quarries and mines; perhaps they can play a part even in mechanical engineering. After all, their application on a small scale in safe breaking (without damage to the contents) is well established. Something may be learned, even from a felony.

Letters to the Editor

TRUST THE BOSS

SIR, Thank you very much indeed for the note which you have written in the Human Element (ENGINEERING, December 28 last, page 832) announcing our recent abandonment of the piecework system. I must add that your analysis is dead right, because I am convinced that the combination of dynamic and autocratic personalities in one individual is almost the ideal mental acquisition needed to secure leadership.

As to your very wise closing remark regarding the difficulty of keeping everyone going on a five-day week, the short answer to this is the facility of mobility of manpower and the knowledge of realising that ahead of us there was a period of time—a long-term policy—in which our resources and facilities would be engaged upon new production projects which, when allied to our own specialised article, would enlarge our scope and keep everyone busily engaged.

Of course, there were other reasons in our minds for wanting to get rid of the old system. One of these was to bring about a lesser disparity in earnings, and another was to meet, above all else the obvious outlook ahead; that of reduced quantity buying on the part of the very many firms who are affected by the credit squeeze and competitive activities overseas. In consequence of these factors, contracts to-day are invariably placed on the basis of "delivery to schedule," which is somewhat meaningless inasmuch as deliveries can be taken now or never, and of manufacturers having to supply quantities which are very small and uneconomical from a production point of view, having regard to the initial volume and value of the contract.

One further point which may interest you is the latest notice we have put up in our works touching the benefits derived by the ex-piece-workers in respect to the earnings they now get during holiday periods, a copy of which is given herewith.

Yours sincerely,
FRANCIS B. WILLMOTT.

Francis B. Willmott (Dalmans) Limited,
Birmingham, 12.
January 7, 1957.

Notice referred to in Mr. Willmott's letter:

"Doubtless it has occurred to you all just how lucky you are to have accepted the change over, when you come to reflect the benefit each of you derives from the Christmas Holiday. For example: when on piecework the rate would vary from 3*s.* 6*d.* to 4*s.* an hour. For 17 hours' holiday pay this would be equivalent to:—£2 19*s.* 6*d.* to £3 8*s.* 0*d.* To-day on the daywork system the holiday pay ranges from £5 6*s.* 3*d.* to £5 10*s.* 6*d.*, representing a net gain of £2 6*s.* 9*d.* to £2 2*s.* 6*d.*

"Now carry this a step further in respect to the fortnight's annual holiday:—2 weeks of 44 hours, or 88 hours, originally at 3*s.* 6*d.* to 4*s.* an hour, ranging from £15 8*s.* 0*d.* to £17 12*s.* 0*d.*; to-day ranging from £27 10*s.* 0*d.* to £28 13*s.* 0*d.* This represents a net gain of £12 2*s.* 0*d.* to £11 0*s.* 0*d.*

"Can you wonder that it is expected from you all to give the maximum output when you have the work to do, and to work with the same enthusiasm as though you are on piecework, realising that an incentive payment has already been given to you in this difference in the holiday pay? The real test will come when we are actually busy, when it will be expecteed that everyone will produce the maximum quantity of which the machines are capable. Meanwhile, when the output is so much less, according to need, then the rate of operation is relatively slower; but I do not want to see that become a habit; and I do not think any man among you is likely to let it become so. As a Business we shall certainly not be in sympathy with anyone who does not pull his weight according to need.

"I am thinking it is better to give each one of you a copy of this memo, because you will be better able to read it in your own time; whereas to have a message conveyed to you, either to read or hear in haste, means to say that it could be forgotten. It is now possible for each of you to retain a copy in your own possession as a record of what the Business has done and is expecting of you. It would not seem inappropriate to add the Nelson touch:—The Business expects every man to do his duty!

"December 27, 1956."

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COLONIAL TRADE UNIONS

SIR, The British engineering industry has a distinguished record in the conduct of industrial relations; and I write to reassure your readers that the two sentences which you quote in the Human Element, on page 800 of your issue of December 21 last, from our chairman's address at the annual meeting of this Federation, do not fully represent either the reputation or the policy of the Federation in the field of collective bargaining.

In another passage Sir Frederick Seaford was able to claim close and continuous relations with the Trades Union Congress—a friendship that is not easily to be won or lightly to be thrust aside—and there were many examples in our annual report (copies of which were available to reporters who attended our meeting) of the many practical ways in which the colonial employer shows consideration to an immature trade union. In spite of the anxious tutelage of the T.U.C., the Colonial Office and local government officials, many union officers still know very little of administration, care less about their financial responsibilities to their own members, and are ready to use trade unions to further their own political ambitions.

One of the greatest of the colonial unions—the Northern Rhodesia African Mineworkers' Union—in twenty months spent £30,000 on objects which called forth the strongest criticism from the recent commission of inquiry into Copperbelt disturbances. And it has just been reported that Sir William Lawther, secretary-treasurer of the Miners' International Federation, is to spend six weeks in Rhodesia to advise the unions on their organisation.

But, after all, we are an employers' federation and our first duty is to our members. We were greatly encouraged when Lord Lloyd, the Parliamentary Under-Secretary of State for the Colonies, also speaking at our annual meeting, said: "I should like to express my appreciation of the special contribution which the Federation is making, in what I may, perhaps, call our joint efforts to create and maintain sound industrial relations in our overseas territories. The job is an exacting and a difficult one, and one that calls for patience and perseverance. The record of the Federation in recent years does, indeed, bear ample evidence that it is not daunted by the magnitude of the job that it has taken on. In this business of preparing the ground for sound industrial organisation, and in ensuring that the growth of self-government within industry is properly rooted, we are, in fact, working to a common end in order to ensure that democratic industrial organisation can move forward and keep pace with constitutional and political development. Genuine freedom of association wisely employed can meet any challenge from systems based on regimentation by Governments. In carrying out this task, it is reassuring to know that we in the Colonial Office, and in the Labour Departments overseas, are not working by ourselves, and that we can look to the Overseas Employers' Federation to help and sustain us in our efforts."

Yours faithfully,
MEREDYTH HYDE-CLARKE,
Secretary.

Overseas Employers' Federation,
London, S.W.1.
January 7, 1957.

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FRUSTRATED LEADERS

SIR, As a member of an industrial enterprise which I have served in both its home and its overseas managements, I should like to sympathise with Mr. Marshall in his frustrating experience (ENGINEERING, December 7 last, page 709), and to make some comments thereon.

While it must be confessed that industrial management to-day has the tendency to become bureaucratic and impersonal, this tendency is surely no more than a symptom of the disease in our Western civilisation which is subordinating the value of human personality to the quest for economic power, success and prosperity. At bottom, the problem is due to the blind pursuit of purely technological progress at an ever-increasing speed, in the course of which the individual inevitably comes to mean less and less. It is also due to a failure of our Western way of living and philosophy, which has made it possible for businessmen to debase human relations instead of promoting them out of a genuine desire for mutual co-operation.

What is the remedy? Obviously, there can be no one solution but I would suggest that far greater care should be exercised in industry itself in the training, selection and promotion of personnel. It should not always be the best worker who is given responsibility, but, rather, the one who knows how to handle people, and who, himself, has real strength of character and personality. Communications from management downwards, and in reverse, should be made clearer, in order to eliminate any possible occasions of mutual distrust and suspicion. On all sides, there should be the will to make good human relations a positive reality. Personnel management as a profession should continue to be given more and more scope, so that its influence for good may make itself increasingly felt.

Industry should not be treated in isolation, of course, and the links already established between it and schools and universities should be strengthened. It is here, I feel, that the real remedy lies, for only in the education of the younger generation, where the seeds for good or ill are sown, can we try to instil the regard for human dignity which we so sadly lack at present.

Yours faithfully,
J. M. ASTLEY.

18 Arun-street,
Arundel.
January 8, 1957.

Weekly Survey

Cover Picture: *Although specialised machine tools are becoming more and more widely used in manufacturing industry, the versatile tool remains indispensible. The illustration shows a multiple turret press for punching holes of any desired shape in steel sheets up to ¼ in. thick. The turret carries 32 different punches—round, square, rectangular and special shapes—but replacement of certain tools is possible, and in addition large and irregular holes may be cut by successive operation. Flexibility is thus almost unlimited.*

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Costs, Prices and Profits Confusion

British industry pays a heavy price for the failure of management on the one hand to disseminate sufficient information about their trading experience and the unwillingness on the other hand of trade unionists to acquire the information systematically. It used to be thought that the main confusion in wage negotiations was the various meanings which could be attached to the idea of gross profits. This confusion, however, is deeper than it first appeared for it extends to the question of prices and costs as well.

Various wage demands are in course of negotiation at the present moment. All of them are at a critical stage or bid fair to be so within a short time. The engineering unions have returned to the employers for further discussion about their 10 per cent. wage demand, with the possibility of militant action in the background despite the unsuccessful efforts last week at York to get the Confederation of Shipbuilding and Engineering Unions to stage a two-day strike. A further blow at the hope of keeping industrial costs comparatively stable despite the Suez crisis was dealt by the National Union of Mine Workers last week when it decided to put forward a demand for an extra 19*s.* 6*d.* a week for all day-wage earners in the industry, a demand which, if met, would cost the coal industry £15½ million a year. The cost of living is always a convenient excuse for a wage demand, but there are continuing signs that organised labour remains dangerously optimistic about the trend of industrial costs, prices and profits.

The miners look at the price of coal in other countries and are impressed with its cheapness in the United Kingdom market. They argue that the price could well rise and that cheap coal is only one stage removed from low wages. There is a bitter irony in this situation for the country as a whole, for here is obviously a clash between the aims of socialist planners and their trade-union allies. There is, of course, a good deal in the miners' argument against a cheap-coal policy but it does not follow because the policy is wrong (if it is wrong) that the miners must be the first beneficiaries from an increased profit margin. For geological reasons coal will become increasingly difficult to win in this country and costs per ton must rise. It would be fatal for the future of the coal industry if the miners were allowed to assume that the economic answer to deep and irregular coal seams was a high cost of living for the miners.

The engineering industry itself is not free from this confusion. Trade unionists speak about average figures as if the price and cost structure of the electrical transformer industry was virtually the same as that of a small company making highly specialised non-ferrous metal parts for a small assembly. It should be known, though it obviously is not, that the giants in the electrical engineering industry operate on small margins and that small specialised firms do not and cannot. When a big electrical engineering group wins a large export order in the dollar market on price, it does not mean that it can afford to cut its prices out of lush profits: it is much more likely to mean that it must keep its turnover up at the risk of small gross margins. These facts must be made known if British industry is not to be crippled by wage increases negotiated on rough-and-ready generalisations which are as dangerous as they are inaccurate.

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Looking into Windows

With the Restrictive Trade Practices Act now on the statute book and the special court set up under the Act due to begin its sittings some time this year, it is bound to be a matter of speculation how far reformed monopolies are being brought about by industrialists making a virtue of necessity. Further light may be shed on this question when the new court comes to examine the restrictive practices registered under the new Act.

The latest industry to be scrutinised and reported upon publicly by the Monopolies Commission is metal windows. The position of the Crittall Manufacturing Company is particularly important in this industry since it accounts for over one-third of metal windows sold in this country. Its activities were therefore especially examined by the Commission. The report finds that there is nothing done by Crittall, arising from its large share of the total trade, which operates against the public interest. The industry, in fact, comes out of the investigation fairly well but it has been wise enough to adjust some of its activities of recent years against the day when the Monopolies Commission would give it official attention. The Metal Window Association accounts for about 90 per cent. of home sales and has 20 members out of the 38 companies in the industry. The output of the industry, however, is much more fully covered by the Association than a counting of units suggests, for three companies, with their associates, account for 70 per cent. of total sales. The Association has operated a common price system since it was established in 1933 and it operated a quota system until 1949. Certain modifications were made in the price arrangements in 1953 which the Commission consider have made these arrangements above criticism from the point of view of the public interest. Criticism is made of the Association's arrangements for reducing prices for particular inquiries when there is possible competition between metal or wood windows. The Commission consider that these arrangements should be brought to an end and should not be replaced by any similar device for meeting competition on a selective basis. Competition is, of course, fairly keen since there is a large demand for wooden window frames and some demand for those made of aluminium. It remains an open question whether the comparatively innocuous activities of the Association over the years have been due to enlightened trade association policy or to the clear threat of competition from alternative materials.

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B.T.H. in 1956

In view of the wide range of interests of the British Thomson-Houston Company, extending from heavy power plant, gearing and switchgear through electrical equipment for transport and a wide range of industries to electronics, including radar navigational equipment, a brief review of developments in 1956 must necessarily be highly selective. An important contract received during the year was that for 330 kV switchgear for the Kariba hydro-electric project which was the largest contract for switchgear from abroad ever placed in this country.

B.T.H. always held a leading position in the design and production of rectifiers and it is possibly in this field that the most outstanding new developments occurred in 1956. These included the application of air-cooled pumpless rectifiers to aluminium refining and developments for high-power semi-conductor rectifiers.

Following an order in the previous year from the Société Pechiney for 78 pumpless rectifiers for part of the power supply for the new aluminium plant at Edea in the French Cameroons, the Canadian British Aluminium Company, Limited, placed an order early in 1956 for a pumpless-rectifier installation for the new aluminium smelter at Baie Comeau on the north shore of the St. Lawrence estuary. This is claimed to be the largest rectifier order ever placed with any British manufacturer. In 1955, B.T.H. completed the first two germanium power rectifiers in Europe and several other germanium rectifiers were finished during 1956. One of these, of particular interest in view of the railway electrification plans in this country, was a 750 kW, 1,500 V rectifier built for trial service on a rail motor coach on the Lancaster-Morecambe-Heysham line. An improved type of germanium cell was introduced during 1956 and the company found it difficult to meet the rapidly growing demand for these cells. A new factory was therefore designed for the manufacture of semi-conductor rectifier cells and a large extension to the general rectifier factory has also been put in hand. Development work has proceeded on silicon rectifiers which are stated to be able to operate at higher temperatures than germanium and to be smaller and lighter.

In the field of turbo-alternators the company's main turbine factory at Larne was taken over from the contractors in November, 1956. A section of the new factory had already been in operation for some time and had been devoted to training. The blading factory at Larne was brought into operation the previous year and by the end of 1956 the output of blades exceeded that from the Rugby blading department. While 1957 may possibly see some decline in the industrial demand for electrical equipment, the expanding nuclear power programme, the high level of shipbuilding construction, the electrification programme on the railways and continued development overseas should assure a high level of activity for the company.

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A New Service

The National Union of Manufacturers have formed a new company, non-profit making and limited by guarantee, to promote the use of modern management techniques among small firms. Their president, Mr. C. S. Garland, spoke of 40,000 firms, employing over 1½ million people and with an aggregate output of goods and services of £2,000 million a year, each employing less than 100 people. These are said to be the main target of the new company. According to Mr. G. L. Page, the managing director, such firms do not generally know anything of work study or cost accounting techniques; they have less specialised knowledge available and their executives are too taken up with detail to see the business as a whole. Few such firms use industrial consultants, for a number of interesting reasons given by Mr. Page.

The basic justification of the new service is that small firms need help, will not seek it from any other source, and without it waste too much of the country's resources. This presumably, was the reason for the grant of £5,000 allocated to the N.U.M. from U.S. Counterpart Funds in 1953—to assist small firms in raising productivity through the use of work study and cost-accounting techniques. Some 250 firms have inquired of the service since its inception. A year ago a further grant of £5,000 was received from the Board of Trade, and additional grants are being sought until the service " can command itself an adequate revenue." For some time now firms have been asked to meet the cost of services they received, and in a reply to a question at the Press conference it was stated that a charge of 30 guineas had been made for a two-day visit by a member of their staff to a firm.

The new company's position *vis-à-vis* management consultants is not yet clear. Mr. G. L.

Page said that since N.U.M. members " so often prefer to come to us in the first instance, we can often diagnose the most effective way of using consultants and guide them in their choice." The daily charges are about half those of the large consultant firms but are made because " firms are more likely to act on advice when paid for." It is difficult to see how the new service will be self-supporting without continued subsidies. On the other hand, if the standard of advice given is high, nothing but good could emerge for all concerned.

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So Far Not So Good

The merger of the two Institutes at Management House is a good opportunity to take stock. The British Institute of Management, which gives its name to the new body, was formed in 1947 with the full support of the Labour Government. It was to supply industry with information and advice on good management practice and to raise the status of Britain's managers to that of a profession. The Institute of Industrial Administration was founded in 1920 and was at the time of the B.I.M.'s inception the only body holding examinations in " general management." Under a formal agreement concluded in 1951 the I.I.A. acted as " the professional wing " of the B.I.M. The merger is little more than an administrative step, which should avoid overlapping and duplication of effort, and simplify the membership and subscription positions. The new B.I.M. will be, as the old was meant to be, " the central national body for the study and promotion of scientific management."

The stock-taking operation does not reflect very favourably either on Management House or on British Industry. The B.I.M. had 4,000 members, including 2,000 corporate members (companies subscribing according to their size, which provided the bulk of the institute's income) and the I.I.A. 3,330. This is a lamentably small proportion of the professional and practicing managers in British industry and commerce. Either the Institute has failed to reach them or has been unable to convince them that membership of a professional body can raise their status or provide useful knowledge of management techniques. In time, however, as the numbers of people who have taken the Institute's diplomas increase, and as more of them reach the senior ranks, the B.I.M.'s influence can be expected to increase. At present the shortage of able managers is such that any employee who shows promise is pushed into a managerial job without there being time to spare him for the duration of a course. An alleviation of the shortage will also tend to make competition for available jobs more keen, thereby increasing the importance of qualifications from a recognised professional body.

The B.I.M. has recently been re-organised, and may emerge stronger and better able to increase its reach and influence in industry. It will, however, have to get along without government subsidy, and rely mainly on its members for its income. Some conditional aid will be granted: in 1955/56 income from this source reached £90,000, a sum unlikely to be adequate for more than a very modest programme. There is an urgent need for a more dynamic and broader approach to industry. The need for good management has never been greater, or more urgent.

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Export Price of Steel Plate

A round of price increases for exported steel products was taken a stage further last week with the announcement of a 6 per cent. increase in the export price of heavy steel plate. The nominal basis export price for heavy plate has been raised to £58 15*s.* a ton f.o.b. for non-Commonwealth markets. The corresponding price of medium plates has been raised to £60 a ton f.o.b. Prices for markets in the Commonwealth will be £1 per ton less. This latest advance follows an increase in Continental export prices announced on December 30, 1956. At that time the prices of a wide range of steel products to countries outside the Schuman area was announced, the price of ships plates going up about 6 per cent. to £61 10*s.* a ton. These represented minimum prices and transactions have been reported at higher prices than these. It will be observed that the increase in export prices for plate follows fairly quickly both on the advance in Continental prices and on those announced for the United Kingdom home market. The new export price keeps in step with the increase in Continental prices but is rather less than the rise in United Kingdom steel prices announced early this month. The price of home-produced plate in this country went up by 10·6 per cent. to £39 2*s.* a ton. The big difference between home and export prices thus remains. It is still almost £20 per ton.

Despite the price advantage which the United Kingdom steel industry has in export markets there is no sign that steel plate is being drawn away in increasing quantities to export markets. A licensing scheme exists to control the export of plate and the trend of exports is, in fact, downwards, although the trend in total steel exports is upward. In November, 1956, 16,500 tons of heavy steel plate were exported, compared with 24,700 tons in November, 1955, and a monthly average of 18,700 tons in the first 11 months of 1956. The steel industry therefore gains only a price advantage from the increase and is not able to sell more plate abroad despite the price differential, while the home market is suffering from a shortage. Under such conditions it is clearly the best policy to increase price without getting too close to the Continental minimum export price.

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Steel Federation Under Fire

Some sections of the steel industry are seeking a larger measure of control over their own destinies. Last week Mr. B. Chetwynd Talbot, chairman of South Durham Steel and Iron Company, challenged the rights of the British Iron and Steel Federation to speak for the industry and negotiate on its behalf. He argued that the interests of the industry—now three-quarter restored to private ownership—demanded that " more direct forms of contact " are established " between the Board of Trade, the Iron and Steel Board and the Industry " on matters of high policy, such as the level of exports, further expansion and price fixation. The previous week Sir Ellis Hunter, chairman of Dorman Long, warned that the difficulties in the way of expanding steel production " should check facile expectations of large steel output increases year by year comparable with those achieved over the past decade." There can be little doubt that this comment referred to the Federation's publication in the January issue of *Steel Review* in which a total capacity of some 28 million tons is envisaged by 1962.

Why this challenge to the Federation which is, in fact, the industry's own trade association? Prior to the Iron and Steel Act of 1953, Mr. Talbot did not question " the correctness of empowering the British Iron and Steel Federation to act as a medium for discussions between the Government of the day and the industry," but he now advocates closer relationships with the Iron and Steel Board (set up by the Labour Government) and with the Government itself. The implications are either that the Federation does not serve satisfactorily as a negotiating instrument—in which case the remedy could surely lie in making it more efficient—or that it is not representative of the industry. In this respect it may be significant that Mr. Talbot and Sir Ellis Hunter's criticisms were not repeated by Sir Walter Benton Jones, chairman of the United Steel Companies.

United Steel were the first undertaking to be denationalised, but Sir Walter had more to say about expansion and rising demand than about difficulties: " there is no doubt that world demand will continue its upward trend and it may well be that supply will lag behind for a considerable time." United Steel expect to contribute 700,000 tons of crude steel towards the 8 million tons estimated additional production required in 5 or 6 years' time. No reference is made to the powers or effectiveness of the Federation. It could be of course that too many of its functions and powers have been taken over by the Iron and Steel Board to allow it to continue effectively. In this case, why the big guns?

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Steelmakers' Problems

The chairmen of three large iron and steel companies have given a good deal of space this year to the industry's special problems. One of the most basic is shortage of capital. The view of Sir Walter Benton Jones of United Steel is that " the speed at which production is to be increased in order to keep in step with rising demand cannot be governed by the rate at which steel companies as a whole are able to save money." To enable the company to proceed with modernisation and expansion as fast as " its development staff can design them " and heavy engineering can supply the plant, United Steel are seeking £9 million from the public. This is the first time a steel company have made an issue since denationalisation, and it will be interesting to see how far investors overcome (or ignore) the political risks generally associated with steel shares. The importance to the industry of such capital is vital. There is little doubt, however, that United Steel's rights issue—six million ordinary £1 shares at 30*s.* per share, in the ratio of three new for every seven held—will be fully taken up. The major problem is that of the smaller less well-known companies who fulfil a most important function in the industry.

United Steel's issue will provide nearly half the cost needed over the next five or six years for three major schemes of development—a strip mill at Steel, Peech & Tozer, an electric melting shop at Samuel Fox and modernisation at the plate works of Appleby-Frodingham. There is a confident expectation in Sir Walter Benton Jones's report of continued prosperity during the current year, when the company should reap the benefit arising from recent capital expenditure (£65 million since 1945-46, or nearly 12 per cent. of the total spent by the industry). The effect of rising costs on the industry's ability to finance its developments is discussed by Mr. Chetwynd Talbot of South Durham Steel and Iron. The company have capital expenditure commitment of some £9·5 million, and Mr. Talbot is highly critical of the low profit margins imposed on the industry by rising costs. Even with the recent increase British steel consuming industries have an 8 per cent. advantage over their foreign competitors in the price paid for steel and, in his view, their criticism of the increase is an attempt " to explain away their own inability to compete in export markets."

Sir Ellis Hunter, chairman of the Dorman Long concern, warns that a " severe shortage of labour " in the North East substantial enough to threaten the planned expansion of the industry on Tees-side. He also refers to the shortage of raw materials and of transport, particularly of ore carrying tonnage. Water supplies and improved inland-transport facilities are other needs of the industry which must be met if expansion is to go on as planned. Yet, as chairman of Redpath Brown, Sir Ellis pointed out that inadequate steel supplies had restricted operations. It is as well that none of the steel makers consider their industry's difficulties as insuperable; there is no need greater or more urgent than the country's need for more steel.

WHY PETROL CONSUMPTION VARIES

By Gordon Wilkins

The present intensified interest in automobile fuel consumption shows up some marked discrepancies between cars in the same class. They have long existed but were not thought important before petrol rationing. In normal times fuel economy is not a major sales argument and differences between one model and another are often masked by differences in the drivers. Within our own experience there is an extreme case where a Renault Dauphine has averaged nearly 45 m.p.g. over 5,000 miles, over the same routes, and at the same average speeds as a previous car of same body size and overall dimensions, but slightly larger engine, which averaged 26 m.p.g. for 35,000 miles.

As a generalisation, the side-valve engine no longer seems to be able to compete on fuel economy with o.h.v. units, and is obviously less able to profit from increases in compression ratio. Recent short-stroke o.h.v. engines do not, however, show any general superiority over the long-stroke units, which had compact combustion chambers, high thermal efficiency and good low-speed torque, thus minimising gear changing. It is only within the past year that British small-car manufacturers seem to have accepted the fact that the smallest possible engine is not necessarily the most economical. Experience with several B.M.C. models which have recently been given larger engines geared to run more slowly bears this out. The Wolseley 15/50 shows a gain of 20 per cent. in m.p.g. at a steady 50 m.p.h. compared with the 4/44 and a much better overall figure. The Austin A35 shows a gain of about 7 per cent. in m.p.g. at 50 m.p.h. and the Morris Minor 1000 about 6 per cent. Overall consumption remains substantially unchanged, although higher average speeds are possible. In other words, gearing for an increase of 11 to 13 per cent. in litres per ton-mile has given the user the option of an appreciable economy with the same performance, or a useful increase in performance without change in fuel consumption.

The design of transmission also has an influence. A four-speed gearbox with exceptionally easy gear shift makes a very high top gear acceptable on the Volkswagen. One of its chief competitors, with about the same engine size, and some 5 per cent. greater weight, has a three-speed gearbox and is geared to give a 40 per cent. higher figure of litres per ton-mile; it also uses about 25 per cent. more fuel in average use. Apart from relative engine efficiencies there are differences in rolling resistance, and the trend to very small wheels has not helped. Some of the oustanding examples of economy occur with the use of larger-than-average wheels.

Some designers achieve good specific consumption by good volumetric and thermal efficiency, and others reduce the power required by low weight, low rolling and wind resistance, while cutting down friction and pumping losses by suitable gearing. They do not always work in the same factory, a fact which was underlined by Professor J. J. Broeze in a paper to the Institution of Mechanical Engineers in 1954, where he began by plotting bench test results of a number of car engines according to a quality number against octane requirement. His quality criterion was (100 × b.m.e.p. at 1,500 r.p.m.) — (max. specific fuel consumption). He went on to plot the corresponding car results on the basis: (Fuel consumption at steady 70 km.h. in litres/100 km.) — acceleration time from 20 to 80 km.h. against octane requirement. The orders on the two graphs were quite different.

Fuel shortages are usually accompanied by a drop in octane number, in the interests of maximum extraction, so that the shortest road to economy—an increase in compression ratio—is closed. British manufacturers are now leading Europe in the use of high compression ratios, and but for the Suez crisis might soon have been using ratios of 9·5 or 10 to 1, as is now done in the U.S.A. Fuel injection (already adopted by Chevrolet) may show up to a 10 per cent. fuel saving in return for higher first cost, and further gains are to be hoped for if various schemes for charge stratification reach practical application.

Combustion naturally also has great influence on fuel consumption and two devices have recently received considerable prominence in the daily Press. Both aim at ensuring that the petrol reaching the cylinder is burnt to the best advantage. One consists simply of a device designed to improve vaporisation (and hence also distribution between cylinders) but the second, by the injection of a small amount of cold atomised mixture which vaporises within the cylinder, improves the turbulence and therefore the completeness of combustion. Considerably improved performance figures are claimed for both devices, though neither are as yet in general use.

Meanwhile, there is still scope for the wider adoption of overdrives, or numerically higher top gears, on small cars.

FAMOUS LONDONERS

Engineers and Scientists to be Commemorated by Plaques

For more than 50 years the London County Council, following a practice which the Royal Society of Arts had already well established, have been marking with blue commemorative plaques the homes of men and women who are famous in history, the arts, science and letters. For many years these plaques were made in the Doulton pottery in Lambeth, and when it closed there was a lapse in the placing of new plaques. Now, however, arrangements have been made with Carter's Tile Company, Limited, of Poole, Dorset, to take over their production, and the L.C.C. have issued a list of 15 new appointments to this London "Honours List." They include several of interest to engineers and scientists.

On No. 51, Manchester-street, W.1, a plaque will be placed to mark the residence there of Rear-Admiral Sir Francis Beaufort (1774-1857), Hydrographer to the Navy from 1829 to 1855, who, in 1805, while commanding H.M.S. Woolwich, devised the "Beaufort scale" for assessing the force of the wind, which is still in use. Thomas Cubitt (1788-1855), the former ship's carpenter who became London's foremost building contractor and was responsible, *inter alia*, for the construction of South Belgravia and Pimlico, is to be commemorated by a plaque on No. 3 Lyall-street, S.W.1. He was one of the guarantors of the Great Exhibition of 1851 and subsequently negotiated the purchase, from its profits, of the sites in Kensington on which the Victoria and Albert Museum, the Science Museum, etc., were built. His workshops in Grosvenor-road, Pimlico, which were the scene of a disastrous fire in 1854, became the works of James Simpson and Company, engineers, and later of Worthington-Simpson, Limited, until their removal to Newark-on-Trent. Cubitt was a Member of the Institution of Civil Engineers and contributed papers to the *Proceedings* on the strength of iron girders and of brick arches. A plaque on No. 53 Stanhope-street, St. Pancras, N.W.1, will commemorate Captain Matthew Flinders (1774-1814), who, having been (in his own words) "induced to go to sea by reading *Robinson Crusoe*," early achieved renown as a hydrographer in the South Seas, charting a great part of the south coast of Australia. For six years he was a prisoner of the French on the island of Mauritius, during which time he wrote a paper for the Royal Society on the effect of iron in a ship on the behaviour of the compass. He was the first man to "swing" a ship for compass adjustment, and his name is perpetuated in every seagoing vessel by the "Flinders bar" of the standard compass, which corrects the deviation that would otherwise be caused by vertical soft iron in its vicinity.

The home of Oliver Heaviside (1850-1925) at 55 Plender-street (formerly King-street), N.W.1, is also to be marked. An outstanding mathematician, though largely self-taught and by nature a recluse, he made notable contributions to electrical theory, including the postulation of the "Heaviside layer" of ionised molecules in the upper atmosphere as the reason why wireless waves follow the curvature of the earth's surface instead of passing straight out into space. He was made a Fellow of the Royal Society in 1891, and in 1922 was the first recipient of the Faraday Medal of the Institution of Electrical Engineers. Finally, and perhaps of the widest appeal to engineers, a plaque is to be placed on No. 11 Granville-park, Lewisham, S.E.13, the residence for many years of Samuel Smiles (1812-1904). It was during his secretaryship of the South Eastern Railway that Smiles went to live in this house, and in it he wrote his *Lives of the Engineers* and most of his other books.

★ ★ ★

FUTURE OF THE DIESEL ENGINE

In a lecture to the Diesel Engineers and Users Association on world supplies of oil, Mr. M. E. Hubbard, B.A., M.I.Mech.E., F.Inst.Pet., reached some interesting conclusions regarding the future of the Diesel engine. After analysing the consumption of petroleum products in the Eastern hemisphere and in Europe since 1938 he showed that the proportion of the European total accounted for by motor spirit has fallen from 49 per cent. to 28 per cent., while the proportion of middle distillates has risen from 17 to 27 per cent. This has been due mainly to the swing from the petrol engine to the Diesel for road transport and has resulted in a marked lack of balance between supply and demand for the various products. Thus, while nearly half a million tons of motor spirit was exported from Europe and the Middle East in 1955 it was necessary to import 4 million tons of middle distillates and 2½ million tons of fuel oil, mainly from dollar areas.

Though the Diesel vehicle is intrinsically more economical than the petrol vehicle Mr. Hubbard shows that, even where the level of tax on the two fuels is the same, the main saving is due to the lower aggregate tax paid. If virtually all road transport in Europe were by petrol vehicles as in the United States and Canada, it would be very much easier from the refinery angle to meet the demand for the various products. The present pattern has already resulted in a steady rise in the price of Diesel and fuel oils while the price of motor spirit has been nearly constant. Leaving tax out of account, the Diesel's economy is greatest when used for stationary purposes (operating for a large proportion of the time) and as a large mobile power unit such as a locomotive. From the point of view of engineers, the main conclusions are that, to ensure maximum supplies, specifications for Diesel fuel should be as wide as possible and the engine, if it is to be sure of adequate food supplies, must be omnivorous.

★ ★ ★

F. G. Miles, Limited, Shoreham Airport, Sussex, have been awarded a contract by the Ministry of Supply for the design and manufacture of the first electronic flight simulator for the Navy's new all-weather fighter, the DH110. The Miles company is the first aircraft manufacturer in Great Britain to enter the flight simulator field.

The Engineering Outlook—3

This week's article continues the series of forecasts of probable trends in various sections of industry during 1957. *It is divided into the five sections listed below. The first and second articles in the series appeared in the issues of January* 4 *and* 11 *respectively.*

SHIPBUILDING
AIRCRAFT
MOTOR VEHICLES
LIGHT ELECTRICAL AND CABLE INDUSTRIES
GENERAL AND CONSTRUCTIONAL

SHIPBUILDING

At no time in the last five years has the United Kingdom shipbuilding industry had less than three years' work in hand, and this condition of over-full employment has tended to obscure a gradual decline in the relative importance of the British industry as compared with that of foreign countries, notably Germany and Japan. It may seem out of place to express concern regarding the future of an industry which, at September 30, 1956, had over four years' work on hand at the current rate of output, yet the fact remains that for the first time since 1920 total launchings in this country were surpassed by those in Japan, while the tonnage launched in German yards was only slightly below the British figure. The nominal capacity of British shipbuilding yards is about 1¾ million gross tons per annum but, as the figures show tonnage completed has not exceeded 1·3 million gross tons in recent years except in 1954, when the figure was just under 1·5 million tons. The main reasons for this have been shortages of materials, particularly steel plate, a restricted labour force and restrictive practices. The strike of 460 joiners at Cammell Laird's Birkenhead shipyard over a dispute as to who should drill holes in aluminium sheeting not only held the British industry up to ridicule abroad, but is unfortunately symptomatic of an attitude of mind which may well slow down or block the introduction of the new techniques which must be introduced if British shipyards are to meet the delivery dates quoted by foreign competitors.

At the same time that there was a rise in the tonnage completed for export in 1956, there was a fall in the export tonnage under construction and more particularly in the export tonnage laid down. In 1955, export tonnage completed amounted to about 45 per cent. of the total, and in 1956 to 58 per cent., but of the tonnage laid down in 1956 only 27 per cent. was for export. Fortunately there was some improvement in export orders received during the first nine months of 1956 which amounted to about 30 per cent. of the total, but this figure is still low in relation to the proportion of export work on hand in previous years.

In the first nine months of 1956, total orders placed with United Kingdom yards amounted to 222 ships of 1,266,000 gross tons, bringing the total order book at the end of September to 5·6 million tons valued at £735 million. This was 900,000 tons higher than the figure for September 30, 1955, and only 1·4 million tons below the peak of 7 million tons reached in June, 1952. By the end of 1956 unofficial estimates put the total of orders on hand at 6 million tons, equivalent to nearly five years' output at current rates.

JAPANESE COMPETITION

The international shipbuilding situation is summarised in Table I. On the basis of tonnage under construction the United Kingdom is still well ahead of all competitors, the figure of 2·1 million tons at September 30, 1956, being nearly twice that of the nearest competitor, Japan, and 2½ times the German total. On the other hand, tonnage launched in the United Kingdom in the first nine months of 1956 at 886,863 gross tons is well below the Japanese figure of 1·2 million tons, and only slightly in excess of the German total of 753,786 gross tons. It is true that the figure for tonnage launched in the United Kingdom over this period was slightly below the average rates maintained in recent years, but the difference was not sufficient to affect the comparison materially, and a stiking feature of Table I is the ratio of tonnage under construction to tonnage launched in the three countries. In the United Kingdom the annual rate of tonnage launched represents only 57 per cent. of the tonnage under construction while for Germany and Japan the corresponding figures are 120 per cent. and 130 per cent. respectively. If the type of construction undertaken in the three countries were the same, these figures would indicate that the rate of building in Germany and Japan is over twice as fast as in the United Kingdom. In practice, while there is a good deal of truth in this conclusion there are also important differences in the character of the work undertaken.

The Japanese shipbuilding industry has tended to concentrate on very large tankers and bulk dry cargo carriers which are much simpler to construct and more readily completed, since they involve less fitting out than either passenger ships or cargo liners, which account for about 40 per cent. of the work in hand at British yards. Rather over 50 per cent. of the work in Japan consists of tankers compared with about 40 per cent. in the United Kingdom, and a high proportion of the tankers under construction in Japan are vessels of large tonnage such as the recently completed Universe Leader of 84,730 tons deadweight. While this may, however, partly explain the apparent competitive advantage of Japanese shipbuilders, large tankers and ore carriers are likely to constitute an increasing proportion of new orders in the future and, if the long term prosperity of British shipbuilding is to be assured, it is essential that British yards should be in a strong competitive position for this class of work. This does not appear to have been the case during the past year. At the launching of the S.S. Evgenia Niarchos from Vickers' Armstrongs Barrow-in-Furness yard in August, it was stated that all recent orders for the Niarchos Group had been placed outside the United Kingdom, and included two large tankers of 65,000 tons deadweight to be built in Germany and eight tankers and three dry cargo ships in Japan.

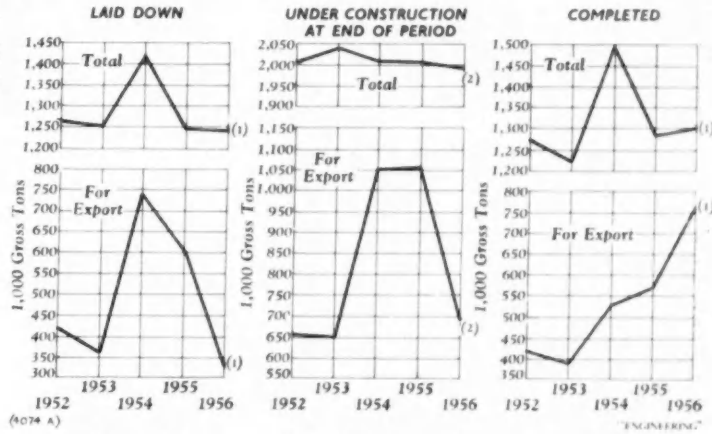
TANKER CAPACITY

In the latter half of 1956, with delivery dates quoted by Japanese and German shipbuilders approaching those offered in the United Kingdom, some important tanker orders were placed in

TABLE I.—*World Shipbuilding: Gross Tonnage Launched and Under Construction, 1956*

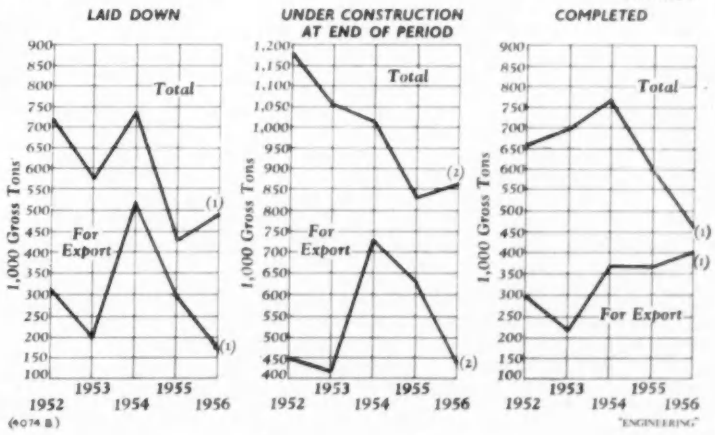
	Launched Jan.-Sept., 1956		Under construction Sept. 30, 1956	
	No.	Tons gross	No.	Tons gross
United Kingdom	196	886,863	333	2,077,976
Other Commonwealth countries	41	44,691	60	175,504
Belgium	14	61,723	19	112,823
Denmark	28	96,157	28	116,109
Finland	21	26,192	49	115,234
France	49	185,897	73	465,462
Germany	308	753,786	250	823,263
Italy	54	284,493	98	670,415
Japan	218	1,177,689	144	1,192,745
Netherlands	122	316,188	175	610,067
Norway	53	136,331	75	249,924
Spain	36	50,159	66	161,896
Sweden	55	281,349	63	398,827
U.S.A.	32	123,073	22	201,865
Other countries	21	57,732	46	126,200
Total	1,248	4,482,323	1,501	7,449,310

Merchant shipbuilding in the United Kingdom. (Thousand Gross Tons).



(1) Estimated on 10 month's figures.
(2) At October 31.

Tanker construction in the United Kingdom. (Thousand Gross Tons).



(1) Estimated on 10 month's figures.
(2) At October 31.

this country, including those of the Peninsular and Oriental Steam Navigation Company valued at £37 million. Hitherto, the large supertankers have been ordered mainly by Greek and other foreign independent owners, but towards the end of 1956 the major oil companies, such as British Tankers and Shell, will include a larger proportion of vessels of 60,000 tons deadweight and over. This has given rise to some anxiety as to the number of British yards capable of building this type of ship, and there can be no doubt that a good deal of reorganisation is necessary if large numbers of these vessels are to be built without impairing the ability of British yards to construct the wide range of other types of vessels which at present constitute the bulk of the orders on hand. The extension of berths presents many difficulties and is bound to take time, but is a problem to which a good deal of thought is being given. For example, Swan, Hunter and Wigham Richardson have in hand an eight-year expansion programme as a result of which it will be possible to build a 100,000 ton tanker in the largest berth and 65,000, 50,000, 38,000, 20,000 and 18,000 ton vessels in the remaining five berths.

It may be argued that the development of a large shipbuilding industry from scratch is an easier problem than that of adapting an existing industry with a large volume of work in hand. Nevertheless, the growth of the Japanese industry in recent years presents an object lesson of what can be achieved. Japanese shipbuilders obtained their first post-war export orders in 1948 and these amounted to only 62,000 tons for the year. In spite of yearly subsidised orders from the Government the industry remained in a state of depression until 1954, but in 1955 output amounted to 800,000 gross tons and in the first nine months of 1956 nearly 1·2 million gross tons were launched.

To some extent this remarkable growth was due to the congestion in United Kingdom and German shipyards and to concealed subsidies, e.g., the allocation of sugar import licences, to Japanese shipbuilders, and there has been a tendency to think that the pressure of Japanese competition will lessen once the advantage of being able to quote early deliveries is removed. With the growth in work on hand, however, there has been a remarkable reduction in costs at Japanese shipyards and by 1955, according to the Japan Shipbuilders' Association, prices had been reduced to 85·5 per cent. of the level in 1951 in spite of a rise of 8 per cent. in the price of steel. This has been achieved largely by improvement of prefabrication and welding techniques, which are claimed to have resulted in a 15 per cent. saving in the consumption of steel and a considerable reduction in the time on slipway. It has been stated that before the war a 40,000 ton vessel spent six months on berth but this figure has now been reduced to less than four months.

While British shipbuilders are assured of capacity working for at least four years, it is clear that a good deal of work remains to be done if longer term prosperity is to be assured. Export orders account for about 70 per cent. of the output of both German and Japanese yards against under 30 per cent. in the case of the United Kingdom. British shipbuilders still have the advantage of cheaper steel than their competitors abroad, and German costs, which have already risen substantially, may well rise further as a result of the recent prolonged strike of 30,000 shipyard metal workers. What is required in this country is a substantial reduction in the actual time required to build a ship, since this is likely to prove the deciding factor in securing export orders when the total volume of orders begins to fall.

AIRCRAFT

The struggle for the world aircraft markets continues unabated. The first surge of buying in the big jet-transport field had already taken place by the time last year's article in this series appeared in April. Purchases of the major transport aircraft have, however, continued at a steady level, and by December, 1956, a total of 1,355 aircraft had been ordered of the 15 major types competing for the medium and long range market. Turbine aircraft now, of course, account for the major part of these orders, and the current generation of piston- and compound-engined aircraft, the Douglas DC7C and Lockheed 1049G and 1649A, represent the piston engine's last bow on the world's trunk routes.

In an industry in which the public have such a large stake—both as to defence and the development of civil aircraft, and which has become so inextricably entangled with questions of national prestige—criticism is bound to be frequently voiced. After the lavish overpraise of the immediate post-war years, during which progress appeared so rapid and spokesmen on every hand never tired of declaring that Britain led the world, the present period must appear even to the informed layman as one of peculiar frustration. Britain pioneered the jet engine and put turbo-jet airliners into service at a time when Americans were only just reconsidering their refusal to operate them; yet of the 324 jet airliners on order in December, only 33 were British. The jet engine opened up new realms of speed in military aircraft, yet British skies are in the future apparently to be defended by one supersonic fighter type at present in the pre-production stage, while by 1958, the American Tactical Air Command will be mainly equipped with the Lockheed F104 Starfighter, already in squadron service and reputedly capable of Mach 2. American swept-wing jet bombers have been produced almost by the thousand, and the first supersonic bomber has recen ly flown in America while two of the three British strategic bombers have yet to enter full service.

Disappointment is bound to be felt, and to be given voice in criticism. A great part of this is grossly misinformed—which is a pity since the situation at least calls for serious thought—and such criticism is liable to give rise to equally nonsensical replies. Criticism from within the industry itself, however, must be given much more weight. In a particularly outspoken lecture in October, 1956, Air Commodore F. R. Banks, formerly principal director of engine research and development at the Ministry of Supply, and now a director of the Bristol Aeroplane Company, Limited, drew particular attention to the question of whether the performance of the industry could be improved by changes in its organisation and scope of projects.

It is too easy to dismiss the very real achievements of the industry, and attempts to do so are damaging. As the Minister of Supply said in reply to a question in the House of Commons in October: "To talk about an inquiry into an industry exporting £100 million in a year in the most competitive market in the world is really wide of the mark." 1956 has, indeed, been a record year for aircraft exports. By the end of August, exports stood at over £73 million and had already exceeded the total for the whole of 1955; the total for 1956 is estimated to have been about £110 million, or nearly double the figure for 1954. The greatest recorded increase has been in the export of complete aircraft and parts, which rose to nearly double the 1955 figures. Though well distributed geographically, the most significant increase lies in deliveries to the United States, which in the first nine months was the largest buyer (£11·5 million). This was closely followed by a large rise in exports to Australia (from £1·5 million to £9·9 million for the first nine months of 1955 and 1956, respectively). Estimated engine exports for 1956 show a more steady, though no less important, rise of £5·3 million to £27·6 million.

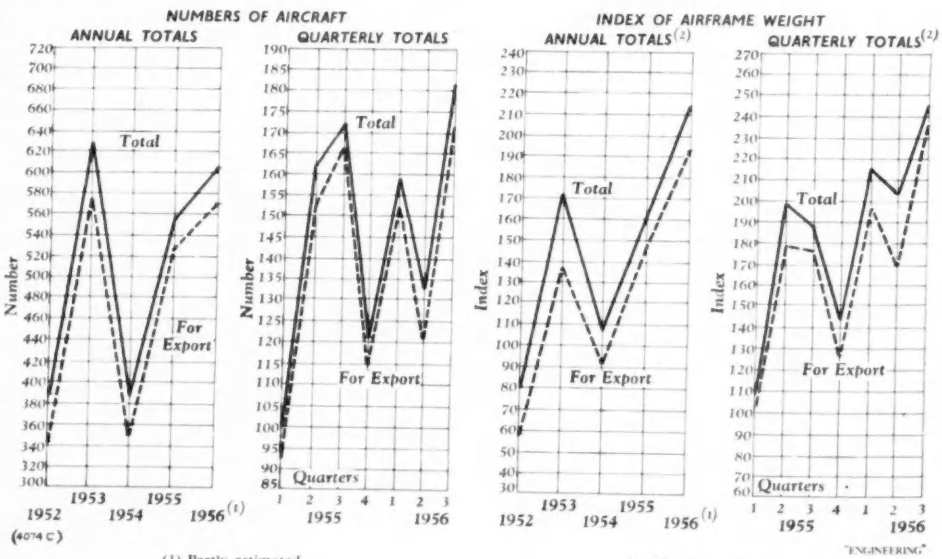
EXPORT ACHIEVEMENTS

This is an impressive performance, but at the same time it is equally wide of the mark at the present time to compare British exports directly with those of continental competitors, a comparison made in another exchange in Parliament. The principal potential competitor on the Continent is France, whose aircraft industry employs a total of only about 60,000 compared with the British total in June last year of 257,300. Both of these are dwarfed by comparison with the American industry, employing around 800,000. Boeing alone are stated to employ nearly 120,000 people, or approaching half the total direct employment in the entire British aircraft industry, while Douglas are even larger. In the Los Angeles-San Diego region are concentrated Douglas, Lockheed, North American Aviation, Northrop, Hughes Aircraft Company and Con-

TABLE II.—*United Kingdom Exports of Aircraft and Equipment.* (£1,000.)

—	1954	1955	1956(*a*)
Aircraft and parts	31,403	39,652	75,599
Engines	20,860	22,242	27,554
Electrical appliances ..	2,085	2,279	2,536
Tyres (outer covers) ..	611	648	655
Aeronautical instruments ..	1,152	1,368	1,371
Total	56,111	66,189	107,715

(*a*) Estimated on nine months



(1) Partly estimated.

(2) Monthly averages.

Deliveries of aircraft, (a) total, (b) for export. The figures exclude military aircraft except those manufactured for export.

vair, with an estimated total employment in the area of over 300,000.

These figures, together with the fact that a large slice of the world market for medium and long range aircraft lies on the American doorstep, emphasise both the magnitude of the problem and the importance of what has already been achieved. Out of a total of 624 propeller-turbine civil aircraft ordered by December, 442 were British. These were made up of 357 Viscounts, 20 Vanguards, and the reassuring total of 65 Britannias. Options have been taken on nine more Britannias, bringing the total near to the quoted break-even figure of 80. The British foothold on the American continent has been strengthened by the contract for 14 Comet IV's and IVA's for Capital Airlines announced in July, by the contract signed in November with Northeast Airlines for five Britannias, and finally by the order in January, 1957, for 20 Vanguards for Trans-Canada Airlines, bringing the total number of Vanguards ordered to 40. Comet deliveries for Capital will start in the later part of 1958, while Northeast's Britannias are due later in 1957. The first Lockheed Electra, is scheduled for delivery in August, 1958.

ONE HUNDRED MILLION PASSENGERS

The civil aircraft market is growing rapidly. The International Air Transport Association anticipates that the world total of passengers carried by air will be more than 90 million in 1957, and will reach 100 million in 1958. On the North Atlantic route alone the passenger total is expected to reach 1 million for the first time in 1957. The 78 million passengers carried in 1956 means that passenger traffic has doubled since the end of 1951. At the same time the cargo ton-miles for 1956 were 1,000 million compared with 518 million for 1950.

This expansion has resulted in heavy buying of civil aircraft in the past two years, during which the pattern of long-range transport for the next decade has been established. The preliminary needs of the airlines for long-range aircraft have been provided for, but many more orders are to be expected. It has been estimated that there is a market for between 100 and 150 big jet aircraft between now and 1962, and for another 100 to 150 in the five years after that, in addition to the orders for nearly 250 which have already been placed. The battle for this market has virtually been lost—perhaps the seal was set on the American victory by the ordering of 15 Boeing 707's for B.O.A.C. in October—unless the Britannia can follow up its success with North-east. This aircraft, if ready earlier, might have tipped the scales in favour of large-scale buying of propeller turbines in place of jets. It will still be in service well before the big jets, and past experience has shown how effective the introduction of an aircraft into service can be as an inducement to placing further orders.

The really important struggle ahead lies in the medium range field; British manufacturers have a clear lead at present. Competition is, however, becoming ever more intense. Of the aircraft already ordered, the Lockheed Electra has sold well, with 129 firm orders by December, 1956, while orders have been placed for 40 Vanguards including the important T.C.A. order. The Fokker Friendship has won orders for 53, while strong efforts are being made to sell the French Caravelle in the United States. Sales of the latter amount at present to only 12 for Air France, but the manufacturers believe it to have a great potential.

The Comet has made a promising start in the American market, but the Americans are also entering the medium-range jet field. Convair early in 1956 announced plans for their type 880 jet transport, saying that the aircraft would be produced if sufficient orders were forthcoming. Firm orders in December stood at 44. In addition, both Douglas and Boeing have started on design work for medium-range jets. These, together with the de Havilland 118 announced last year, and the Convair 540 with Napier Eland propeller turbines, are at present without orders, though it is clearly the firm intention of B.O.A.C. to purchase a substantial number of de Havilland 118's. The borrowing powers of B.O.A.C. were enlarged by the Air Corporations Act, 1956, to cover the purchase of these and of the Boeing 707's.

A further British competitor in this field was announced in September, in the shape of a medium-range pressurised freighter-coach projected by the Hawker-Siddeley Group. This aircraft, to be designed under the technical direction of Sir Arnold Hall, will carry 66 passengers, or the freight equivalent, over 2,000 nautical miles, and will be powered by either four Rolls-Royce Darts or two of the Tynes, which are to be used also in the Vanguard. This aircraft will be developed as a private venture.

SHORT-RANGE JETS

The tendency to consider jet aircraft for medium and short-range operations is growing, but the final answer to this must lie in detailed consideration of each particular airline's requirements. It has been effectively demonstrated over the last two years, however, how little an airline dares to ignore its competitors' equipment. A major decision by one company can set off a chain reaction. It is this matter of intense competition for passengers' favours against a background of fixed fares, particularly when, as is the case in Britain, logical thought is allowed to be clouded by questions of national prestige, that can force airlines further than they may really want to go. As a whole, the airlines of world are hardly in a strong economic position—overall operating profit margins amount to 1·1 per cent.—and the big jets will pose considerable problems in the airports they are intended to use. Yet B.O.A.C. have finally been compelled to purchase them in order to have a chance of maintaining their share of the traffic. The D.H.118 is specifically designed to use shorter runways, but by the time this aircraft is ready, the world's major airports will have had to be expanded to take the giants.

With this situation, where does the British aircraft industry stand ? The answer to this is inextricably bound up with defence. The Air Estimates for 1956-57 already showed some cutback, and pressure for radical cuts in defence spending are likely to grow and to carry more weight. Suez has demonstrated that this country is not to be allowed to fight minor wars, and cogent arguments have been put forward to prove that it could not possibly afford to fight a major one. In these circumstances, the dead weight of a defence expenditure which, per head of the population, is nearly double the average for Western Europe, will appear less and less justifiable. Whatever the merits of these arguments, they are bound to carry increasing weight. Any cut in defence spending would bear heavily on the aircraft industry, not only in the immediate future but in the long term. An appreciable part of British aircraft exports are of semi-obsolete military types. It is at least probable that the present development programme for military aircraft is the minimum consistent with the maintenance of a home-produced air force of any effectiveness. The next generation of major fighter aircraft is represented by the P.1, the Saunders-Roe mixed power plant interceptor, and the recently announced Hawker private venture, while A. V. Roe are reported to hold the sole contract for a supersonic bomber.

The guided missile programme has already been radically pruned. The question to be decided appears therefore to be whether it is intended to have a completely home-produced R.A.F. If it is decided to concentrate the British industry's efforts on a more limited range of types, some degree of collaboration between existing companies appears almost inevitable. This has been firmly forecast by Rear-Admiral Sir Matthew Slattery, the chairman and managing director of Short Brothers and Harland; he believes that collaboration will be essential, not only because there will not be enough projects to go round, but also because no design teams are at present, or are likely to be, large enough to complete the design of increasingly complex aircraft in a reasonable time.

It must also be borne clearly in mind that future British civil aircraft depend heavily on research carried out in connection with military projects, and that the amount of research expenditure necessary is continually growing.

PRIVATE VENTURES

In any case, it is a welcome sign that an increasing number of major projects are being undertaken as private ventures. This is a wholly reassuring return to bold private enterprise, and at the same time an attempt, in at least one case, to circumvent the delays that have dogged official projects. Two of these private projects, the Folland Gnat and the Vickers Vanguard, have met with well-deserved success.

In the major battle for world markets for civil aircraft, therefore, Britain faces severely competitive conditions. In the medium-range market, the British industry is well placed. In the long-range field, Sir George Edwards has gone so far as to say that the only hope is to plan for the potential supersonic market some 10 or 12 years hence. While this may be thought to be pessimistic, the prospects in the more immediate future are problematical.

In the field of feeder liners, the Dove and Heron continue to sell well, and there is promise of further orders for the Herald and for the Twin Pioneer. The Fairey Rotodyne should fly early this year, and holds out the promise of eonomical inter-city transport. Two new agricultural aircraft were introduced last year, by Auster Aircraft and Edgar Percival.

It is, however, in aircraft engines that Britain's prospects are perhaps most secure. Out of the ten different types of gas-turbine airliner on order to-day only one, the Convair 880, is not at present available with British engines, and it is understood that this aircraft also may eventually be offered with the Rolls-Royce Avon as an alternative power unit. With the large market for the present generation of gas-turbine airliners extending over at least the next ten years, the British manufacturers thus have excellent prospects in this new field, particularly as several of the engines are only at the beginning of their development life. Meanwhile, the Napier Eland has good prospects of a market in the projected Convair 540, and Napiers are making a bid for re-engining with the Eland many hundreds of piston-engined aircraft now flying. The Short S.C.1 project announced in December also demonstrates an aspect of British engine development, since British thinking on vertical take-off centres on the use of multiple low-thrust engines of low specific weight, represented in this case by the Rolls-Royce RB108. This is a long-term project, but may assume great importance in the next decade, with the advent of large supersonic aircraft.

Overall, therefore, this is a time of challenge for the aircraft industry. The achievements made so far in some fields have been great, and generally underestimated. The aircraft industry is still young and, if the initial pioneering spirit can be fostered and not stifled by ill-informed criticism, the great difficulties ahead can yet be overcome.

MOTOR VEHICLES

The motor industry enters 1957 in an unhappy atmosphere. To the restrictions imposed earlier in the year on hire-purchase and rental agreements at home, and the growing intensity of competition abroad, must now be added the effects of petrol rationing on the domestic and European markets, and the Suez crisis on the demand from the Eastern hemisphere. The addition totals a gloomy sum of cuts in production, reduced turnover and profits, and widespread short-time working and redundancy in the British motor industry to-day. Figures of output are only

available for the first ten months of 1956, but they reveal the extent of the industry's difficulties. Production of passenger cars and chassis probably fell by 20 per cent. in 1956, while commercial vehicle output was down by 11 per cent. compared with 1955. (The graph shows the trend of production during the last five years.) Production for export shows a similar trend, although the fall is not so marked as in output for the domestic market. For the overseas market, production of both cars and commercial vehicles was down by 7 per cent. in 1956. Although the value of commercial vehicles sent abroad rose slightly last year, it is understood that new orders being received from abroad are following the general downward trend. The prosperity of the commercial vehicle industry in the earlier months of the year was evidently not being maintained in the latter part of 1956.

Nevertheless, motor manufacturers, while admitting short-term difficulties, are still confident regarding long-term prospects. Answering possible criticisms of over-optimism as shown by the expansion plans of the industry, Sir Leonard Lord, chairman of the British Motor Corporation, said in November, 1956, that he was still convinced of the need to instal improved production facilities. To proceed with expansion along these lines was the only way of meeting growing competition from abroad and ensuring a prosperous market at home. This is undoubtedly true in so far as it relates to modernisation of manufacturing plant with a view to cost reduction, but the capital required to achieve a substantial further increase in productive capacity may not be easy to find in present circumstances. Profits of the British Motor Corporation fell by 42 per cent. last year, while net profits of Rootes Motors, Limited, fell by 46 per cent. and those of the Standard Motor Company, Limited, by 77 per cent.

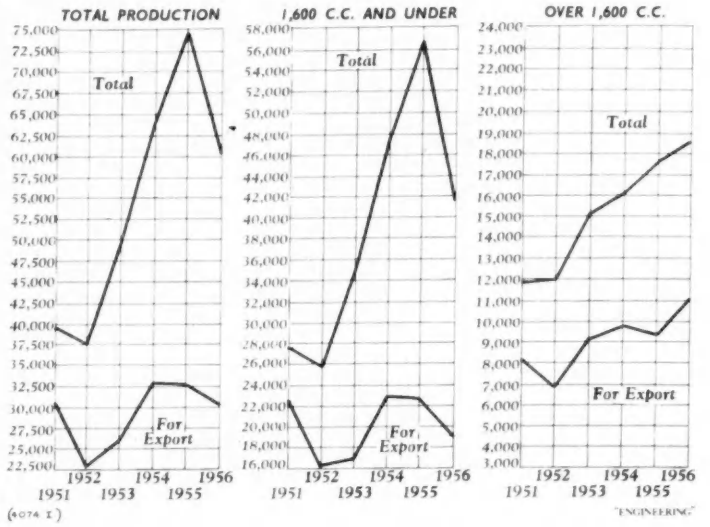
CHALLENGE FROM ALL SIDES

Seldom since the war has the motor industry had to face such a challenge. A long, hard and painful pull has to be accepted by both management and labour alike. As regards the latter, the industry will not go forward in normal conditions, let alone face the current difficulties, if the unions continue to oppose technological change or press for increased wages without a corresponding rise in production. Standards attribute a large share of their poor results in 1956 to the prolonged strike at Banner Lane during re-tooling last May, and B.M.C.'s results were undoubtedly affected to some degree by the troubles at Longfield in the summer of 1956. At the beginning of this year it was Briggs Motor Bodies, Limited, who were in trouble with their labour force owing to a proposal to instal a new shift-working system at their Dagenham factory. The unions must realise that if the motor industry is to make the attempt to cure its malaise in 1957, success is in a large part dependent on their co-operation.

In the field of overseas sales, it is even more evident that co-operation is needed if the industry is going to succeed abroad. European markets are being affected by the petrol shortage, which can only mean even fiercer competition from Germany, France and Italy. By comparison with the performance of the British motor industry in 1956, the attention of the Press and the public has persistently been drawn to German successes over the past year. In particular, the Volkswagen company had another successful year despite their own difficulties in the home and export market. Production at Wolfsburg is estimated to have risen by a further 20 per cent. to 395,211 units in 1956, and the company expect to sell 450,000 vehicles in 1957. In the export field their achievement is even more impressive. Foreign sales rose by over 23 per cent. to 218,540 vehicles in 1956, and represented 55 per cent. of total output. Even more intensive competition can be expected from this source in 1957, particularly in European markets. Neither have German manufacturers been slow to seize opportunities elsewhere. Plans to establish a Mercedes factory in the Lebanon are said to be nearing completion and, should this scheme go ahead, a monthly output of 500 vehicles is expected from a factory near Beirut to furnish material for a sales drive in the Middle East.

Production of passenger cars and chassis, 1951-1956. (Monthly averages : numbers).

(1956 figures, appertaining to first 10 month's average).



Production of commercial vehicles and chassis, 1951-1956. (Monthly averages : numbers).

(1956 figures appertaining to first 10 month's average).

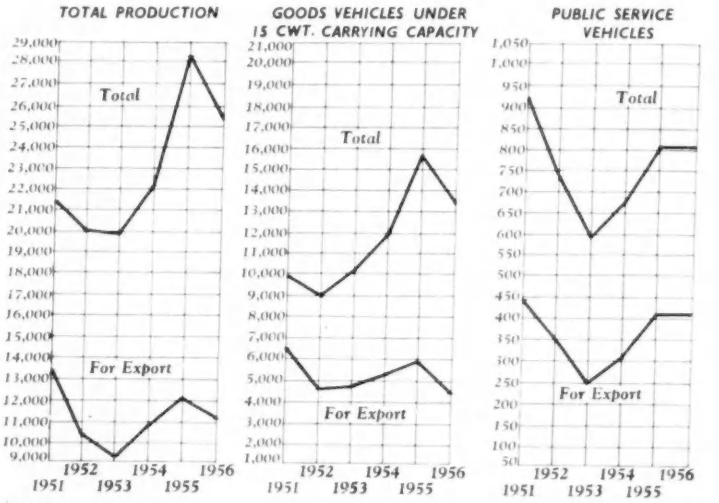


TABLE III.—United Kingdom : Exports of New Vehicles, Chassis and Parts
(Value £1,000)

	Cars		Commercial vehicles		Total	
	1955	1956 (*a*)	1955	1956 (*a*)	1955	1956 (*a*)
Complete vehicles and chassis						
Union of South Africa	8,259	7,720	7,445	7,612	15,704	15,332
Rhodesia and Nyasaland	4,234	3,720	2,663	3,044	6,897	6,764
Australia	26,172	17,220	13,352	10,804	39,524	28,024
New Zealand	12,499	5,484	4,843	4,364	17,342	9,848
Canada	5,264	8,048	560	924	5,824	8,972
Other Commonwealth countries	17,776	16,444	23,063	31,460	40,839	47,904
Irish Republic	5,645	2,828	2,448	2,040	8,093	4,868
Sweden	6,108	6,800	635	312	6,743	7,112
Denmark	2,190	2,852	1,509	1,612	3,699	4,464
Netherlands	3,836	3,604	2,732	2,684	6,568	6,288
Belgium	4,369	5,428	2,010	2,060	6,379	7,488
U.S.A.	9,205	13,840	497	852	9,702	14,692
Other foreign countries	16,911	21,308	24,069	27,152	40,980	48,460
Total	122,468	115,296	85,826	94,920	208,294	210,216
Parts	—	—	—	—	48,983	56,812
Grand total	—	—	—	—	257,277	267,028

(*a*) Nine months' annual rate.

Meanwhile France, facing a recession in her own motor industry, is also intensifying her foreign efforts. Success for the Renault is certainly in evidence in the United States market. Their sales are estimated to have tripled there during the first nine months of 1956. The Swedish company, Volvo, have also announced that since production may have to be cut by as much as 30 per cent. owing to the petrol crisis, they will make special efforts to develop their newly established markets in the United States and South America.

Countries which hitherto have been considered unimportant in motor vehicle production are also coming to the fore. Interest has been shown over the last few years in new models developing in Czechoslovakia and Eastern Germany. The Opel is an example of the latter country's success in export markets. Another example of the newer countries in the motor industry is Japan. One Japanese manufacturer, the Komatzu Manufacturing Company, announced plans last year for the production of a new " peoples car " selling at £300. Another leading Japanese motor manufacturer, the Toyota Jidosha Kogyo Company, announced in August, 1956, that it will soon complete the test model of a £450 car designed for the middle-class market in Japan and in other Far Eastern countries.

The examples given above are necessarily only a very brief and incomplete summary of the sort of competition British manufacturers will have to face in an already difficult export market in 1957. The main problem is where the spearhead of the export effort should aim. Deliveries to the Antipodes are being lengthened and otherwise made more difficult by the closure of the Suez Canal, and it is evident that the growing Australian car industry will assume increasing predominance in that area. South Africa has in the past been a good market, but the government will in all probability maintain its policy of encouraging indigenous assembly and has recently increased the import quotas of some foreign manufacturers. In the Middle East, British sales may be adversely affected by "prestige" considerations, and in the Far East Japanese competition will have to be faced sooner or later. Meanwhile the European market is bound to shrink during petrol rationing.

The one bright spot in this somewhat gloomy picture lies in the Dollar Area. United Kingdom exports of passenger cars to Canada rose by over 50 per cent. in 1956 and there was a 50 per cent. rise in exports to the United States—though here it should be noted that new registrations of the Volkswagen in the United States doubled last year. In the field of commercial vehicles also, exports to North America, though small compared to total exports, are increasing. Last year commercial vehicle sales to the United States and Canada combined totalled 1,776 units, an increase of 68 per cent. over the previous year. Activity in the United States automobile industry is at present increasing and prospects in that market must be considered good in 1957.

In South America, however, British sales of passenger cars are declining rapidly, and with continued exchange restrictions and the encouragement of local assembly from local materials, notably in Brazil, any reversal of the trend will be difficult to achieve. In this connection while Standard have a small assembly plant in Brazil, and the Austin Motor Company, Limited, announced plans for local production in Columbia last year, American and German manufacturers are developing local production on a much larger scale.

Constructional activity is still running at a high level throughout the world, and the future is rather more hopeful for manufacturers of commercial vehicles, particularly in the heavy range over 6 tons. It is in this range that concentrated efforts need to be made by vehicle manufacturers, and the need becomes even more pressing as the demand for lighter vehicles becomes more seriously affected by petrol rationing at home and indigenous manufacture abroad.

Technical developments made during the past year have tended to be overshadowed by the economic problems of the industry. There is little space to comment upon them here, but brief mention may be made of two interesting developments. To meet motorists' problems arising out of the petrol shortage Austins have produced a new "pick-up" version of the A35 saloon, for which exceptional performance has been claimed, and the British Anzani Engineering Company, Limited, are producing the "Astra Economic Utility." The latter is a light commercial vehicle said to be capable of 60 m.p.g. at normal cruising speeds.

LIGHT ELECTRICAL AND CABLE INDUSTRIES

Apart from the motor industry, certain sections of the light electrical engineering industry have been the most severely affected by the credit squeeze. The fall in sales which began in the latter part of 1955 continued during the past year, but towards the end of 1956 there were signs of some recovery in certain sections of the industry, e.g., in sales of radio and television sets. It would appear that the public were becoming accustomed to the higher prices resulting from increased purchase tax and to the hire purchase restrictions, and that the strong long-term rise in demand was beginning to assert itself in spite of the restrictions imposed. In the absence of the additional strain on the national economy due to the Suez crisis the industry might have looked for some relaxation in these restrictions during the current year, and there can be little doubt that when any such relaxation takes place a strong backlog of demand will make itself felt, provided, of course, that the dislocations due to oil shortage do not result in a major fall in the purchasing power of the public.

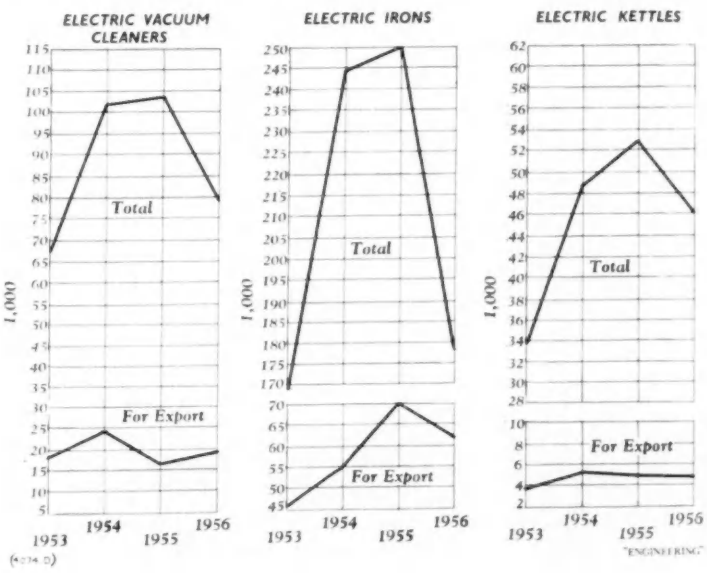
In contrast to the light electrical industry, cable manufacturers have experienced a prosperous year in 1956 and have been particularly successful in expanding exports.

At the beginning of 1956 there were considerable stocks of radio and television sets on hand and for this reason the recovery in sales in the latter part of 1956 was not immediately reflected in production. For the first half of 1956, sales of radio sets were over 20 per cent. below the corresponding figure for 1955, while sales of television sets declined by 14 per cent. For each of the months July, August and September, however, sales of television sets were higher than in the corresponding months of 1955 and it was estimated that for the year as a whole sales of television sets would about equal those for 1955, while sales of radio sets would show a decline of about 10 per cent. For the reason given above, the production statistics as shown below are less satisfactory, but some increase in output may well be expected in the current year. The fact that sales of radio sets were so well maintained in spite of the restrictions owes a good deal to the introduction of v.h.f. radio transmission. It was announced in August, 1956, that, since the opening of the first v.h.f.

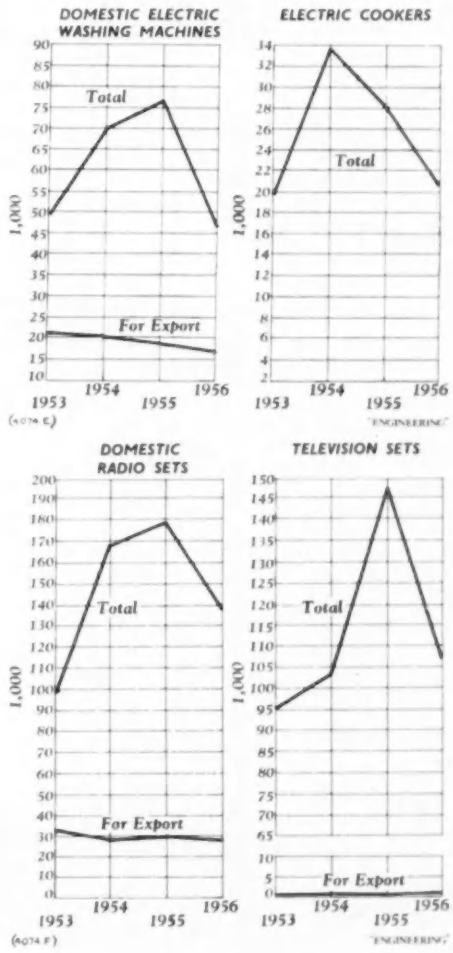
TABLE IV.—*United Kingdom Exports of Light Electrical Goods and Apparatus and of Telegraph and Telephone Cables.* (*Value £1,000*)

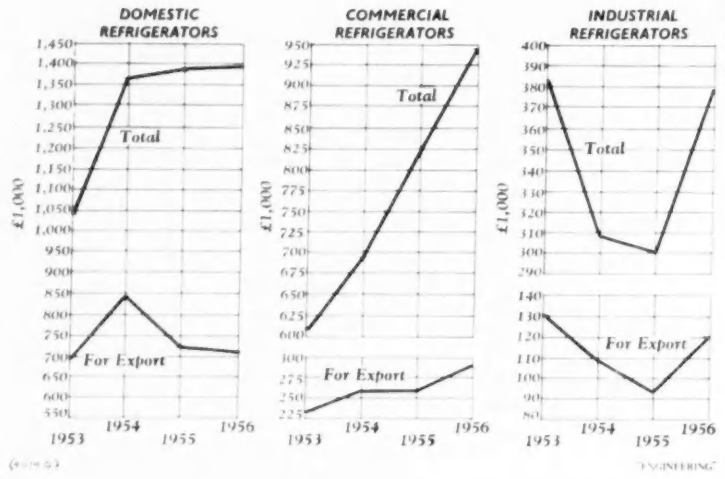
—	1954	1955	1956(*a*)
Electronic valves and radio, television, radar and sound reproducing apparatus	25,995	28,208	32,579
Telephone and telegraph apparatus	15,133	15,821	18,984
Electric light bulbs and tubes	2,239	2,516	2,637
Electric light apparatus and appliances	4,714	5,110	5,565
Batteries, primary, complete	3,100	3,479	4,449
Accumulators, complete	3,195	3,346	4,063
Electrical cooking and heating appliances	3,912	4,971	4,612
Electrical instruments	4,355	4,751	4,804
Electromedical apparatus	1,113	1,372	1,595
Refrigerating machines	15,262	14,484	15,275
Vacuum cleaners	2,030	1,575	1,700
Total	81,048	85,633	96,263
Telegraph and telephone cables and wires:			
Submarine	771	862	2,116
Other	3,796	6,393	10,072
Other descriptions of cables:			
Cotton, silk or artificial silk insulated	439	591	620
Enamel, glass or asbestos insulated	874	930	1,198
Paper insulated	6,128	9,718	11,020
Rubber insulated	4,646	5,746	6,323
Thermoplastic insulated (*b*)	—	1,044	1,658
Other	2,736	2,467	2,636
Total	19,390	27,751	35,653

(*a*) Partly estimated.
(*b*) Not separately distinguished prior to 1955.

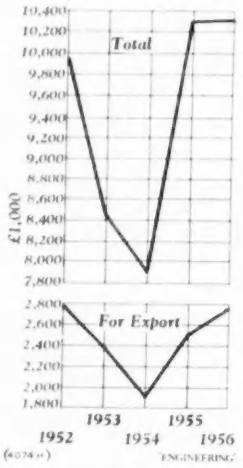


Average monthly output of domestic electrical appliances in the United Kingdom (Thousands).





Monthly average output of refrigerators in the United Kingdom. (£1,000).



Monthly average output of wires and cables in the United Kingdom. (£1,000).

service in May, 1955, a total of 450,000 v.h.f. radio sets and radiogramophones had been sold.

Other branches of the radio and electronics industry fared a good deal better than that devoted to radio and television sets, and manufacturers whose interests were well spread were to a large extent able to offset declining revenue from those fields by increased income from other sources. Total exports of electronic valves and radio, television, radar and sound reproducing apparatus rose from £28·2 million in 1955 to an estimated £32·6 million in 1956. Of this total, radio communication and navigational aid equipment and radar equipment is estimated to have accounted for nearly £15 million, an increase of about 20 per cent. compared with the previous year. It is not surprising, therefore, that some companies whose main interests have hitherto been concerned with radio and television have taken steps to broaden their activities into the field of telecommunications. One such company is A. C. Cossor who, in October, 1956, formed a new subsidiary, Cossor Communications Company, Limited.

VALVE PRICES

As a result of the Restrictive Trade Practices Act the British Radio Valve Manufacturers Association announced in October, 1956, that all arrangements for collective resale price maintenance had been discontinued after 30 years of price control. It was considered unlikely, however, in view of the recession in the industry and the consequent rise in costs, that this would result in any immediate reduction in prices. There had already been a substantial reduction in the prices of replacement television tubes and radio valves to the public earlier in the year. Some indication of the long-term growth of the industry was given by the President of the Association in November when he stated that the production of valves for the broadcast entertainment field in 1955 was five times the 1938 figures, for the services seven times and for industrial purposes 30 times. The total production of valves in 1955 was about 64 million, and of cathode ray tubes 2·25 million.

Attention has already been drawn to the very satisfactory rise in exports of radio, television, radar and sound reproducing apparatus shown in Table IV. While radio communication equipment, navigational aid and radar equipment accounted for 45 per cent. of these exports, other important groups were valves and cathode ray tubes (6 per cent.), and domestic radio receiving sets, radiogramophones and television sets (12 per cent.). For the group as a whole, the principal markets in the first nine months of the year were Australia, which accounted for exports valued at £1·7 million, the Netherlands £1·6 million and India, Canada and France each £1·4 million. Exports to the United States showed a welcome increase from £368,000 to £633,000.

An important contribution to these exports was made by Decca Marine Radar for which orders had reached 6,000 by December, 1956. The introduction by this company of their new True Motion Radar TM.46 (described in ENGINEERING issue of November 9, 1956, page 597) should help to maintain the predominance of British manufacturers in this field.

Manufacturers of radio valves and communication equipment are beginning to experience competition from the development of manufacturing plants in important overseas markets. It was announced in April, 1956, that an electronics factory was under construction in India at Bangalore and would be in full production by the end of 1957. It was expected that by 1961 output from this factory would replace all imports into India of communication equipment and parts for the various defence establishments, which have averaged about 500 million rupees in recent years. Technical collaboration is being provided by a French company, the Cie Generale de Telegraphie Sans Fil. About 30 per cent. of the machinery and equipment for the factory was obtained from France, the remainder being imported from the United Kingdom, the United States and Germany.

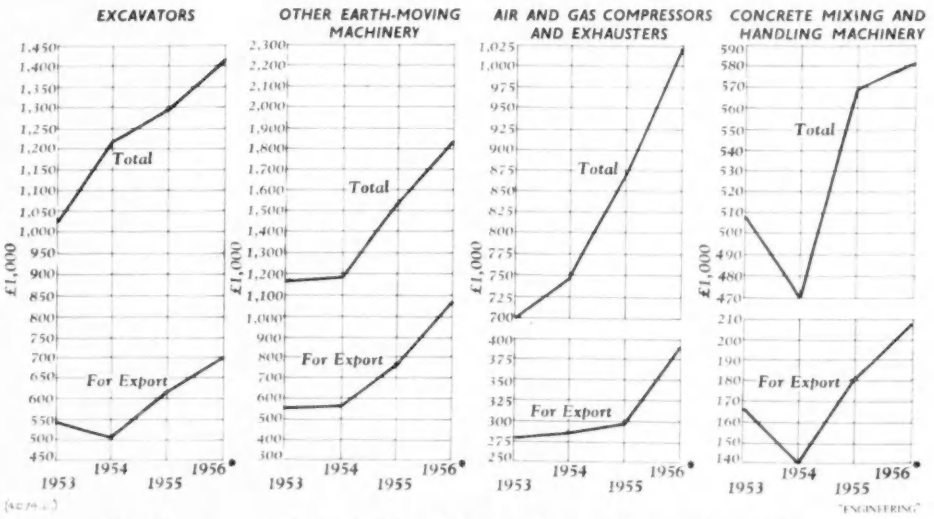
DOMESTIC APPLIANCES

The output of all domestic electric appliances showed a fairly substantial fall in 1956. In the case of vacuum cleaners the fall in home sales was partly offset by a small rise in exports, but in other cases exports were also below the 1955 level. The fact that it was not possible to expand exports of most domestic electric appliances in order to offset the falling home demand was undoubtedly a disappointment to manufacturers, who were anxious to avoid loss of skilled labour. The chairman of Morphy Richards Limited in November, 1956, stated that the company had been faced with intense export competition particularly from Germany, and that credit and import restrictions had severely curtailed sales to Australia, South Africa, India and Burma. In contrast to other domestic appliances, output of domestic refrigerators, shown in the graph, rose slightly in 1956. Refrigerator manufacturers in that field had a prosperous year, the output of commercial refrigerators showing an increase of 15 per cent. and that of industrial refrigerators a rise of 25 per cent. So far as domestic refrigerators are concerned the maintenance of sales in the face of increased purchase tax and hire purchase restrictions probably owes a good deal to the efforts of the Domestic Refrigeration Development Committee, which was set up early in 1956 to promote home and export sales. Members of the committee include eight of the leading manufacturers who claim to represent about 80 per cent. of total production.

Somewhat surprisingly in view of the high proportion of the total output used in motor vehicles, the output of accumulators showed a decline of only about 5 per cent. in the first nine months of 1956. There were two reasons for this, namely an increase in exports between 1955 and 1956 from £3·3 million to £4·1 million, and the fact that the demand for replacement accumulators is higher than the new demand in motor vehicles, since it is probable that three or four accumulators are used over the whole life of a car. Much the same considerations apply to dry batteries, for which the main market is in radio sets and torches. Here, however, the replacement market is relatively even more important than with accumulators, and output in the first nine months of 1956 rose by 11 per cent. Exports as shown in Table IV rose from £3·5 million in 1955 to an estimated £4·4 million in 1956.

IMPROVEMENT IN CABLES

After falling steadily between 1952 and 1954, the output of insulated wires and cables showed a



Monthly average output of civil engineering and contracting plant. (£1,000).

substantial increase in 1955, and the high level of production was maintained in 1956. Over the past three years total exports of wire and cables have risen by more than £16 million, the largest increases having taken place in exports of telegraph and telephone cables and of paper insulated cables. While these exports are well spread over a wide range of countries, by far the most important market is India which accounted for exports valued at £4·4 million out of the total of £35·7 million. The continued progress of Indian electrification schemes under the five-year plan should provide opportunities for a further expansion of exports to that country over the next few years. Other important markets in 1956 were New Zealand, Canada and Venezuela.

Some important contracts for cables were received during 1956, and there would appear to be good prospects for the maintenance of exports at a high level during 1957. The Kariba hydro-electric scheme in the Federation of Rhodesia and Nyasaland has given rise to substantial orders for cables; the total value of orders received by British Insulated Callenders Cables Limited from this source amounts to £3¼ million. Towards the end of 1956, Standard Telephones and Cables Limited received a contract valued at £2·3 million for the supply and erection of co-axial cable in Portugal, a country which has in the last few years bought British cables to the value of only about £200,000 per annum.

In view of the wide range of products covered by this section of the engineering industry, it is difficult to attempt an assessment of prospects in 1957. There is little hope of any substantial rise in output of domestic electric appliances, at any rate before the latter part of the year. There is some evidence of a recovery in demand for radio and television sets, but little prospect that this will raise output even to the level of 1955. Manufacturers of accumulators are likely to be hit if, as now appears likely, petrol rationing in this country and in Europe is prolonged. On the other hand, there are good prospects for further expansion in both radio communications and radar equipment and in the output of cables.

GENERAL AND CONSTRUCTIONAL

In addition to the sections of the engineering industry already covered, there remains a wide field which, if for reasons of limitations on space alone, cannot be reviewed in the same degree of detail. The credit and other restrictions imposed in 1955, and intensified in 1956, were designed to reduce the load on an over-full economy and, by restricting home demand, to permit an expansion of exports and thus bring about an improvement in the balance of payments. Considering the industrial picture as a whole, the primary object would seem to have been achieved but at the expense of a cessation of the expansion of industrial production as a whole.

In the engineering industries, those branches most severely affected by the decline in home demand have on the whole been those which found it most difficult to expand exports, while other branches of the industry with a strong export demand have found it difficult to meet this demand owing to continued shortage of manpower. One fact emphasised by the experience of 1956 is the need for some means of accelerating the transfer of labour from those industries with declining output. Between June, 1955, and June, 1956, for example, there was an increase in employment in the manufacture of motor vehicles and cycles, though output of private cars showed a marked fall from February, 1956, onwards. This was, of course, due to the reluctance of employers to part with skilled men until it was quite clear that the recession was more than temporary, and also to attempts by the unions to spread employment over a shorter working week rather than to countenance a reduction in the labour force. Coupled with the time required to train men in a new industry, this has meant that few branches of the engineering industry have obtained much benefit during 1956 from the slight easing of the labour supply. The position should improve in this respect in 1957, however, since between June and September, 1956, employment in the manufacture of vehicles fell by over 14,000. In the radio industry employment adjusted itself more rapidly to declining output, and fell between January and September by about 16,000. Branches of the engineering industry which showed an increase in employment between June, 1955, and June, 1956, include shipbuilding (about 8,000) machine tools (5,000), constructional engineering (1,700), boilers and boiler house plant (1,500) and other non-electrical engineering (20,000). Electrical machinery showed an increase of 6,400, and telephone and telegraph apparatus and other electrical goods an increase of 5,000.

The expansion of employment in general engineering is reflected in the substantial rise in exports recorded in Table V from a total of £167·4 million in 1955 for the products shown, to an estimated figure of £181·4 million in 1956. The largest increases were recorded by cranes, hoists and other lifting machinery; excavating and similar digging machinery; office machinery; pulp and paper-making machinery; sewing machines and scientific instruments. The first two categories reflect the high level of activity in constructional engineering and contracting work which has persisted throughout the world, of which further evidence is shown in the graphs, page 80. The increased output of excavators and other earth-moving machinery and of concrete-mixing and handling machinery is almost entirely accounted for by increased production for export, though production for the home market was well maintained between 1955 and 1956.

DECLINE IN BUILDING EXPECTED

The value of work done by building and civil engineering contractors in the United Kingdom in the first nine months of 1956 was £1,538 million, compared with £1,373 million in the corresponding period of 1955, but there were indications that the rate of increase was tending to fall off. Throughout 1956 the value of industrial building plans approved was well below the corresponding level for 1955 as also was the value of contracts on which work started. Some decline in building and civil engineering work at home must therefore be expected during the current year.

In overseas markets, while the allocation of the main contract in connection with the Kariba hydro-electric scheme to an Italian company was a disappointment to British contractors, the latter have nevertheless maintained a high level of activity. The value of work done in the year ending March 31, 1956, amounted to £78 million, compared with £68·3 million in the previous year, while the volume of work outstanding at March 31 totalled £98·6 million in 1956 compared with £60·2 million in 1955. Moreover the volume of work done in dollar areas rose from 5 per cent. of the total in 1954/55 to 20 per cent. in 1955/56, mainly as the result of successful tendering in Canada. This represents the success-

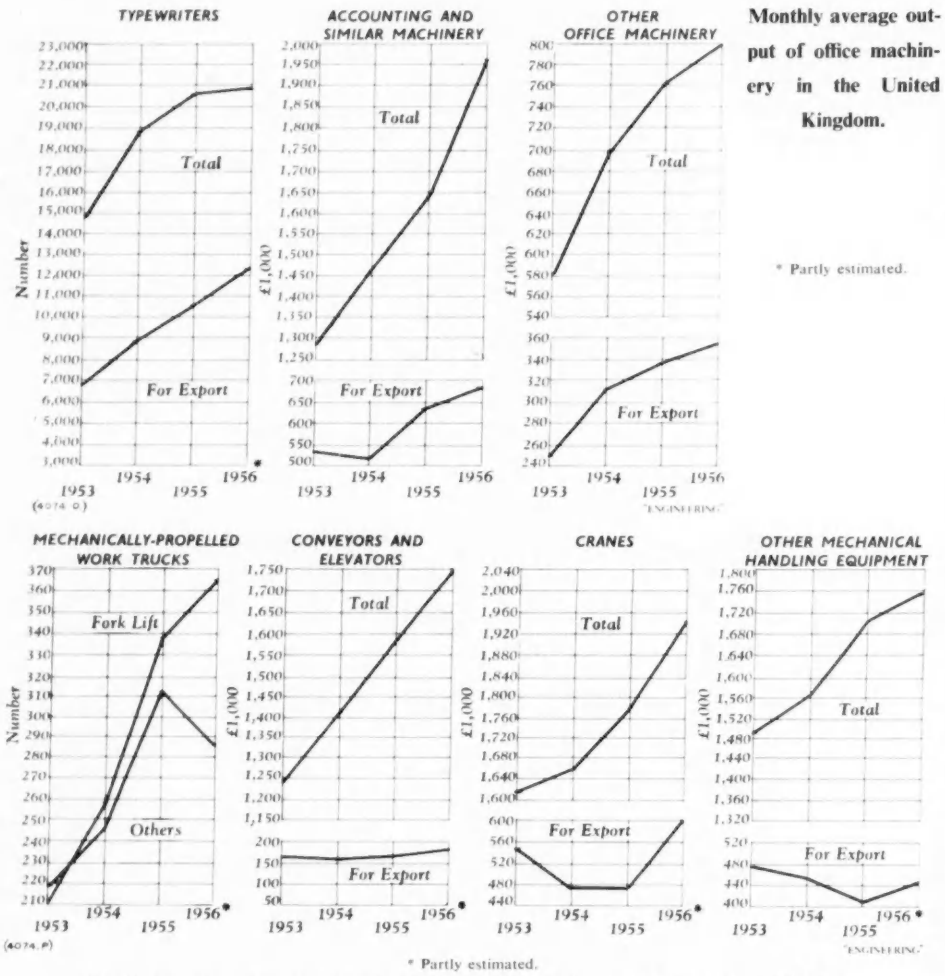
Monthly average output of clocks, watches and pedal cycles in the United Kingdom.

* Partly estimated

TABLE V.—United Kingdom: Exports of Some Industries, Classified as "General Engineering."
(Value £1,000)

	1952	1953	1954	1955	1956 (a)
Air and gas compressors and exhausters	5,284	4,986	5,157	5,388	6,165
Boot and shoe machinery	902	885	958	1,162	1,066
Cement-making machinery	1,796	1,445	988	1,134	1,139
Centrifugal drying machinery	769	817	709	879	801
Concrete mixing machinery	1,389	1,301	1,117	1,597	1,805
Condensers	599	788	890	758	650
Cranes, hoists and other lifting machinery	10,754	12,234	11,836	11,682	13,491
Dairy machinery	1,883	1,122	1,382	2,009	2,555
Excavating and similar digging machinery	14,250	16,111	14,893	18,907	22,983
Fans, power driven	2,515	2,715	2,574	2,763	3,460
Food preparation and sterilising machinery	5,011	4,538	4,238	4,527	5,255
Furnace plant	1,518	1,473	1,404	2,999	1,525
Gas and chemical machinery	2,207	2,229	2,486	2,801	2,188
Grain-milling machinery	2,477	2,059	2,040	2,283	2,804
Hydraulic machinery	1,357	913	789	1,255	1,397
Laundering and dry-cleaning machinery	7,113	6,030	6,757	7,488	7,314
Lawn mowers	1,651	1,542	1,827	2,034	1,855
Office machinery	9,681	11,094	12,192	14,790	15,571
Packing, packeting and labelling machinery	3,386	2,883	3,523	4,820	5,485
Portable power tools	3,825	3,794	4,174	5,313	5,845
Printing and book-binding machinery	9,300	8,509	9,061	9,874	10,245
Pulp and papermaking machinery	3,204	4,119	4,086	4,068	3,243
Pumps	13,299	13,496	13,250	13,795	15,564
Road rollers	1,570	1,610	1,658	2,086	2,322
Sewing machines and parts	8,315	7,297	8,046	9,699	11,100
Sugar-making and refinery machinery	2,819	2,426	3,656	2,271	2,454
Tobacco and cigarette-making machines	2,880	3,385	4,273	3,842	3,505
Weighing machinery	1,646	1,606	1,495	1,708	1,826
Welding machinery	2,365	2,421	1,797	1,895	2,567
Woodworking machinery	2,517	2,077	1,875	2,128	2,447
Ball and roller bearings	3,176	3,620	3,864	4,523	5,181
Opthalmic instruments	648	698	794	780	631
Medical and surgical instruments	1,861	1,776	2,071	2,282	2,328
All other scientific instruments	9,243	9,968	11,018	12,274	13,121
Clocks and watches	1,123	1,050	1,342	1,604	1,544
Total	142,333	142,917	141,220	167,418	181,432

(a) Partly estimated.



* Partly estimated.

Monthly average output of mechanical handling equipment in the United Kingdom.

ful culmination of several disappointing years in which a number of British civil engineering contractors had been attempting to establish themselves in the Canadian market. Progress in overseas markets in this field is necessarily slow since contractors have a lot to learn about local conditions, but there are undoubtedly good opportunities in a number of overseas countries. The Board of Trade, for example, drew attention in September, 1956, to the fact that a large number of building and civil engineering projects are under way or being planned in Australia, but expressed disappointment that British contractors are not as yet more active there. Another source of disappointment is that Britain's share of orders from projects financed by the World Bank appears to be declining.

As shown on the graph above, the output of office machinery enjoyed a further expansion to record levels in 1956, though in the case of typewriters it is clear that the steady expansion of the last few years is now levelling off, and in fact production for the home market showed a decline in 1956. The total production of office machinery is now at the rate of over £40 million per annum, and may well double over the next year or two as the result of the development of production of computers. The ten United Kingdom companies at present manufacturing electronic computers had orders on hand in November, 1956, amounting to £14 million, and their production plans for 1958 envisage an output of between 300 and 400 machines worth more than £30 million. By then there will probably be another six to eight manufacturers in the field, and total production may well equal that of conventional office machinery.

PEDAL CYCLES

As shown on page 79 the output of pedal cycles showed a sharp decline in 1956 to a level below that of any of the preceding three years. The decline was almost equally divided between the home and export markets. For the first nine months of 1956 total exports of cycles fell back to approximately the same level as in the corresponding period of 1954, representing a fall of about 10 per cent. in number and 5 per cent. in value on the corresponding figures for 1955. This fall was entirely due to reduced exports to the United States and other countries on the American continent. The probability of such a fall was forecast in this series last year as a result of the revision of the American import tariff, but in practice this does not appear to have been the only cause. Strong competition has been experienced from European manufacturers, and Western Germany is now the largest supplier of cycles to the United States market. While British exports to other markets have been well maintained it would seem to be only a matter of time before German competition makes itself felt elsewhere. Tube Investments, Limited, the largest cycle manufacturer, announced in September, 1956, that as a result of the reorganisation of its four cycle subsidiaries into the British Cycle Corporation, 1,250 employees would become redundant over the next six months.

British cycles have in the past usually been very competitive in export markets and, since the industry is not at a disadvantage *vis-a-vis* competitors as regards the prices paid for the principal raw materials, the reason for the present difficulties in export markets must be sought in the organisation of the industry or in the level of wages paid. The chairman of Raleigh Industries Limited pointed out in December, 1956, that since November, 1950, no less than six national wage awards have been made totalling over £3 per week for each male employee, representing an increase of 57 per cent. on the consolidated rate. To some extent, of course, these increases represented delayed adjustment to the devaluation of sterling in 1947, though a more important factor was probably the state of over full employment which has prevailed in the last few years. The experience of the cycle industry, however, highlights the two main problems now facing the engineering industry as a whole, namely, the need to restrict wage increases to levels justified by increases in productivity, and to remove all obstructions to efficient production whether these arise on the management side or from opposition by the unions to redundancy caused by the introduction of new machinery or new methods of production.

★ ★ ★

OPEN SKIES FOR PEACE

The Scope of Aerial Photography

At the " summit " conference at Geneva in July, 1955, President Eisenhower proposed to the Soviet Union that they and the United States should take the first teps towards disarmament, in the following words:—

. . . " To give to each other a complete blueprint of our military establishments, from beginning to end, from one end of our countries to the other; lay out the establishments and provide the blueprints to each other.

" Next, to provide within our countries facilities for aerial photography to the other country —we to provide you the facilities within our country, ample facilities for aerial reconnaissance, where you can make all the pictures you choose and take them to your country to study, you to provide exactly the same facilities for us and we to make these examinations, and by this step to convince the world that we are providing as between ourselves against the possibility of great surprise attack, thus lessening danger and relaxing tension. Likewise we will make more easily attainable a comprehensive and effective system of inspection and disarmament, because what I propose, I assure you, would be but a beginning. . . ."

To demonstrate to the public how effective aerial photography can be as a means for military inspection, the Embassy of the United States are presenting the " Open Skies for Peace " exhibition currently in London at the Royal Exchange, until January 26, and subsequently in Manchester, Birmingham, Bradford, Leicester, Bristol, Belfast, and Cardiff. The exhibition includes photographs taken by the United States Air Force in Boeing RB47 reconnaissance aircraft equipped with seven cameras for taking split-vertical, true vertical, trimetrogon (one vertical and two oblique cameras giving a ground picture from horizon to horizon) and forward oblique photographs. From a height of 40,000 ft., 1 million square miles can thus be photographed in 3 hours; and from the records a skilled interpreter can derive a mass of detailed and quantitative information on military installations in the area covered.

On the other hand, low-altitude photography is also widely used now for oblique shots, and some examples of some work recently carried out by the Italian Air Force are on view. A recent development, the " sonne-strip," makes possible clear continuous pictures from low altitudes at very high speeds. To take this type of photograph, the shutter of the camera remains open and the film moves continuously past a narrow strip, the film movement being synchronised with the aircraft's speed over the ground.

Also shown are photographs taken with a new type of film which " finds " camouflaged installations on the ground. All living vegetation which contains natural chlorophyll shows up in red on the film, all else appearing as a dull grey-green, making detection easy.

The exhibition also shows that repeated photographs of the same subject, taken over a period of weeks or months, enable the photo-interpreter to detect changes which have taken place on the ground. By comparing the progress pictures, the analyst can describe quite accurately what has occurred during the period.

THE EXPERIMENTAL SPIRIT

4—CONDENSING; VALVES AND VALVE GEARS

By C. R. H. Simpson, A.I.LOCO.E.

The fourth of a series of articles on unsuccessful experiments to make the steam locomotive competitive with electric and Diesel traction. The first three articles appeared on page 610, *November* 16, *page* 674, *November* 30, *and page* 808, *December* 28, 1956.

CONDENSING

Though condensing has been extensively applied to locomotives, the equipment has almost invariably been provided either to improve conditions in tunnels—as in the early days of the Metropolitan and District Railways—or to conserve water in territory where it was scarce, e.g. in the Argentine. Probably the first serious attempt to use condensing for this purpose was made on the Sudan Military Railways. In 1897 they received from the Hunslet Engine Company four 2-6-2 locomotives (S.M.R. Nos. 16-20) which had a separate condenser between the engine and the tender (as illustrated). This arrangement had the advantage that when water was ultimately discovered at intermediate stations, the condensing vehicle was easily removed and normal working instituted. It had the disadvantage of separating the engine from the tender, which necessitated carrying the 5 tons of fuel on the engine in what at first sight appeared to be very long side tanks. The journals of the trailing truck were only 4½ in. in diameter and as the load on this truck was greater than that on coupled axles the trailing truck boxes were always hot. The condensing vehicle had a wheelbase of 6 ft. 6 in. and weighed 17 tons 3 cwt. There were 2,745 condenser tubes of ¾ in. outside diameter, providing a surface of 3,847 sq. ft. This was another application of forced draught, as air drawn through the condenser was passed through a duct to the back of the ashpan.

As condensing to conserve water was not intended to improve locomotive performance no further consideration is necessary here. Condensing to improve thermal efficiency, however, has had some application in turning of part of the exhaust into the feed water to heat it. Such arrangements were employed by Wm. Stroudley and D. Drummond; the latter have been referred to under the heading of feed-water heating. Condensing to improve power output has been applied in Britain to only one locomotive of the Stephenson form, the Armstrong 2-2-2 of 1848,[70] and to the Ljungström,[71] Read-Ramsay, and Reid-MacLeod turbine locomotives.

Tests carried out in Sweden, where conditions at some periods of the year are particularly favourable for condensing, showed that the rate of condensation of steam on a Ljungström locomotive, the turbine of which could develop 1,800 h.p. at 9,200 r.p.m. and in which the condenser was air-cooled, was 14,250 lb. per hr. The cooling surface available was 10,750 sq. ft., the air delivered by the fans amounted to 15·1 million cub. ft. per hr., and the average vacuum maintained was between 26 and 27 in., resulting in a back pressure of about 1¼ in.

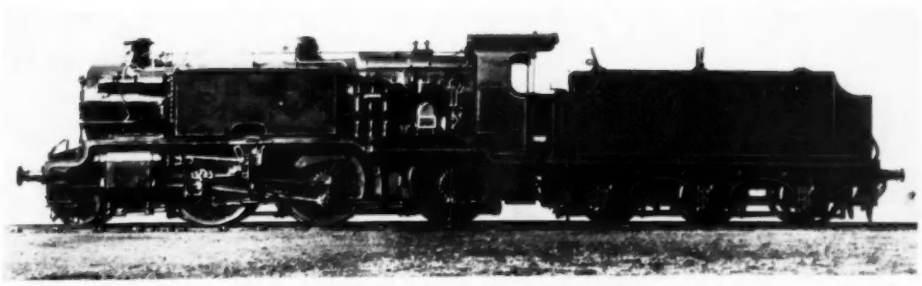
In the Ramsay locomotive the condenser operated on the evaporative principle. The total h.p. developed on a stationary test at Horwich was 730. Steam condensed per hour was 12,730 lb. and the area of the condenser amounted to 2,300 sq. ft. Vacuum was maintained at 25·2 in.

Comparing the condensation in lb. per sq. ft. per hr., this was 5·54 for the Ramsay evaporative condenser and 1·33 for the Ljungström condenser.[72] However, although the former produced better results and occupied less space it does not appear to have been such a good proposition from the maintenance aspect. As the tests referred to were conducted when stationary, an ample supply of water was presumably available, for the evaporative condenser has the disadvantage of requiring about as much water as that required for boiler feed.[73]

In theory, the advantages to be derived from condensing were great. As an example, a locomotive working at 250 lb. per sq. in. was stated[74] to have a limiting efficiency of about 32·5 per cent. condensing, against 18·8 per cent. non-condensing—an increase in favour of the condensing engine of about 72·9 per cent. Assuming equal relative efficiencies of the two locomotives this implied a direct saving of 42 per cent. of the fuel. In practice the difficulties were too great; for locomotive purposes a condenser has to be small, light, cheap in first cost and maintenance, and reliable; in addition, it must give constant performance under varying conditions, have adequate capacity, and demand low power for draught. Furthermore, the absence of blast necessitates the installation of a fan and its subsequent maintenance. It is hardly to be wondered at that condensing—as a means of increasing efficiency—was not pursued.

The subject of condensing locomotives was considered at some length in a paper presented to the Institution of Mechanical Engineers by Dr. G. V. Lomonosoff and Capt. G. Lomonosoff in May, 1944.

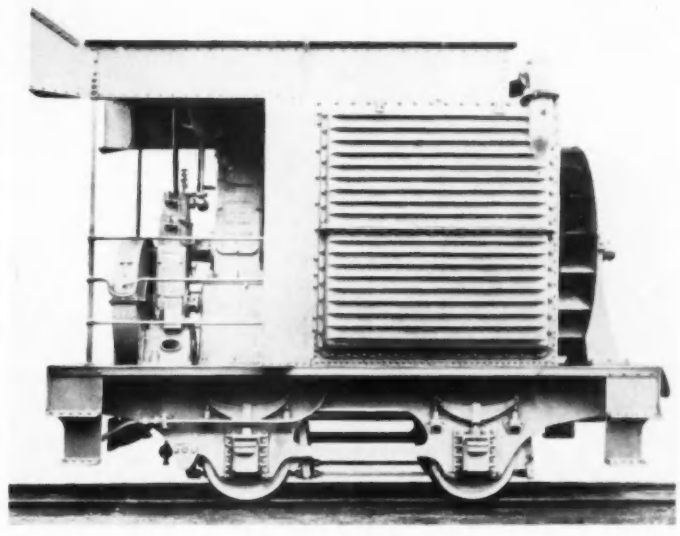
In 1930 Mr. Maunsell fitted to Southern Railway locomotive No. A 816 the Steam Heat Conservation Company's equipment for conserving latent heat (illustrated below). With this system the whole of the exhaust steam was passed through the tubes of a specially designed cooler in which, instead of being condensed and thereby parting with all its latent heat, its heat content was slightly lowered. The steam, still retaining a large proportion of its latent heat, was returned in a super-saturated state to the boiler. The purpose of this idea was to save fuel. On test, difficulty was experienced in obtaining sufficient draught with the fan installed, and unreliability rendered the experiments inconclusive; so they were discontinued.



Locomotive fitted with heat conservation equipment.

VALVES

Much thought and many experiments have been devoted to improving steam distribution. But while the forms of valve in use to-day, and the valve events, differ considerably from those employed at the beginning of the century, the gears most widely used in Britain, namely Stephenson's and Walschaerts, both date from the days of George Stephenson. Those responsible for the design of British locomotives have frequently been accused of conservatism in the trial of new ideas; an example is to be found in Walschaerts gear. Its use became general on the Continent about 1860 and many locomotives so fitted were built in Britain for export; but with two or three exceptions, where the results obtained were poor due to a lack of understanding of the gear's functioning, no use was made of it in Britain until 1890.



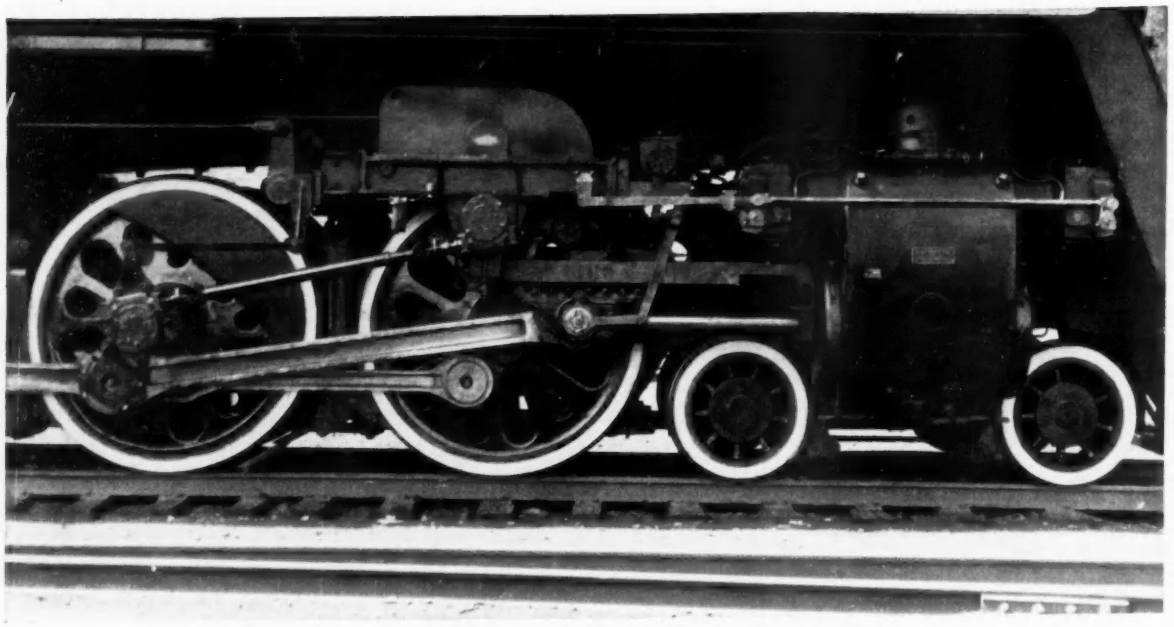
Separate condensing vehicle.

Alterations in valve design were largely devoted to relieving pressure on the valve by balancing, and among the balanced valves may be mentioned Wilson, Richardson and American single or double disc. Trick ports were sometimes employed, for both slide and piston valves. The L. & N.W.R. "Claughton" class were among engines fitted with the latter, which sometimes became choked with carbonised oil. The Wilson balanced valve had supplementary ports for both admission and exhaust.

To improve the cylinder performance of existing locomotives, while retaining the original cylinders, piston valve chambers were produced which could replace the existing steam chest, thus converting from slide to piston valve with a minimum of expense. In later years the Dominion Engineering Company, Limited, produced housings which could be bolted to the ends of piston valve chambers to convert piston valve locomotives to poppet valve (shown on page 82). This device was tried by the Canadian National Railways and while it was not without merit it was not proceeded with, which was hardly surprising in view of the large-scale change-over to Diesel traction then imminent.

Poppet valves are not included here as their use is now established and would become more widespread were the cost not relatively high.

In the early days of superheating both balanced



Conversion from piston valves to poppet valves on a Canadian locomotive.

and unbalanced slide valves were used in conjunction with superheated steam. It will be evident that proper lubrication presented difficulties, to overcome which George Hughes provided mechanical lubrication via passages drilled in the cylinder port faces. This was said to give satisfactory results on non-stop runs of up to 70 minutes duration,[75] but the superiority of the piston valve, which arose from absence of load between the valve and the face of the sleeve,[76] soon exerted itself, to the exclusion of slide valves for superheated locomotives.

Some of the early piston valves designed by Schmidt and used on German locomotives had solid rings moving in steam jacketed liners. It will be appreciated that for such a valve to work freely without leakage, extraordinarily accurate fitting was called for. Experiments on a Belgian locomotive using this type of valve revealed leakage on a standing engine of nearly 1500 kg/h.![77]

To give a freer exhaust, J. A. F. Aspinall applied, to locomotives on the Lancashire and Yorkshire Railway, balanced valves—somewhat similar to the successful American Fay-Richardson valve—which were designed to allow the exhaust to pass directly from the port through the back of the valve, to the blast pipe. Attempts to improve slide valves were, of course, terminated by the large scale introduction of piston valves.

Corliss valve gear was used in France, 13 locomotives of the Paris Orleans Railway being so fitted in 1892-95, and also in America. In the Continental application, two admission and two exhaust valves per cylinder were operated by Gooch gear; in the American examples Young used an amended form of Stephenson's gear to actuate one admission and one exhaust valve per cylinder. The French experiments ended with the universal adoption in France of the De Glehn compounds, and the American applications were short-lived.

As a means of reducing the amount of valve motion required on a four-cylinder engine the Dutch Central Railway in 1910 introduced some locomotives (Nos. 71-74) in which two cylinders had a common steam chest containing a double piston valve, two valves being arranged in tandem on a common spindle, as shown in the drawing.[78]

The Trofinoff piston valve[79] was fitted to locomotives in Italy, Germany, Spain and France, and was at one period standard on the Russian Railways. It was known in Britain as the T.A.B. (Trofinoff Auto Bye-Passing) piston valve and was introduced on the Metropolitan Railway when locomotive No. 94 was so equipped in 1930. The valve had two floating heads which were held against the spindle ends by steam pressure when the regulator was open but which remained stationary at about the centre of the steam-chest when steam was shut off. The object was to leave the steam ports uncovered when coasting. Carbonised oil has proved the undoing of more than one idea which on paper appeared attractive, and it proved a serious obstacle in this instance.

In 1920 the Great Northern Railway had no less than 76 superheated locomotives running with balanced slide valves. At first it was considered necessary to introduce the valve lubricant under the face, via drilled ports, but this practice was later abandoned.[80]

Sleeve valves were tried experimentally by Mr. O. V. S. Bulleid on S.R. 4-4-2 locomotive No. 2039 in 1949, prior to their being fitted on the short-lived " Leader " class. A slight rotary motion was imparted to the valve as it reciprocated. The results were unsatisfactory, as they had been when Cecil Paget of the Midland Railway applied sleeve valves to his 2-6-2 eight-cylinder locomotive. In Paget's design a rotary motion only was imparted and seizure of the sleeve assembly resulted in a major and final failure.

The French State Railways, in the early years of this century, had some two-cylinder compounds on the Nadal system. Two piston valves per cylinder were provided, one for admission and the other exhaust.[81]

VALVE GEARS

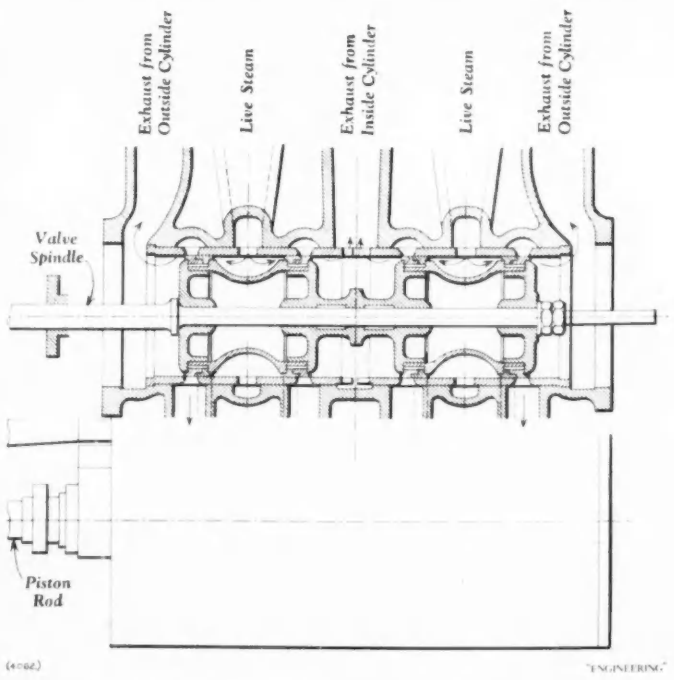
The number of valve gears which have been tried, to a greater or less extent, in locomotive practice exceeds one hundred;[82] it is possible here to refer to only some of them.

The aim of J. T. Marshall was to provide rapid opening and closing of the valve, and slow travel when the ports were fully open —an effect achieved by Joy some twenty years earlier. The Marshall gear, however, derived its motion from two eccentrics, and the vertical loading applied to the connecting rod in the Joy gear was avoided. It is shown opposite, and should not be confused with F. C. Marshall's gear. It was used on the E. and W.J., G.N., and G.S. and W. Railways. The last use of this gear was for the inside cylinder of the 0-8-0T locomotives built by the Southern Railway in 1930.

Several cross-driven valve gears have been used, where the motion for one valve was derived from the crosshead of the other cylinder. Examples were: R. M. Deeley's gear, which although designed as far back as 1887 was not employed until 1907, when it was fitted to Midland Railway 4-4-0 locomotives; G. J. Churchward's gear on the G.W.R. " North Star," which retained this from 1906 to 1930; and O. W. Young's gear, used in America from about 1916 to 1925, which was another crosshead-driven gear, in which each crosshead imparted valve movement equal to lap plus lead on its own side and valve travel on the opposite side. This last gear gave good valve events and long travel (9 in.) but was too expensive for general use.[83]

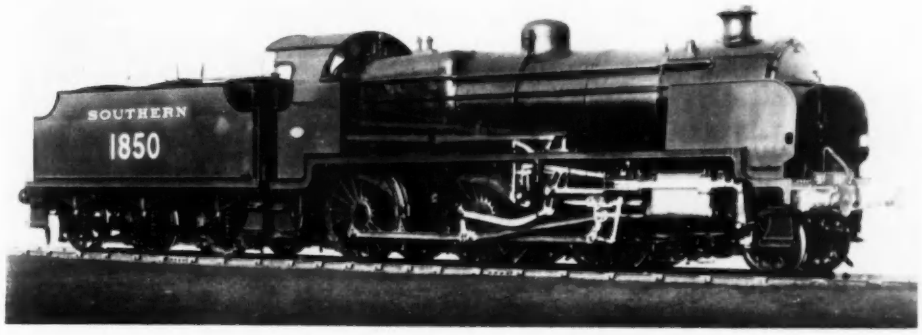
Shortcomings of all cross-driven gears were that in the event of one side failing, the engine was a total failure; and in the event of the locomotive stopping with one crank on a dead centre, starting was a problem.

Trouble with broken connecting rods on

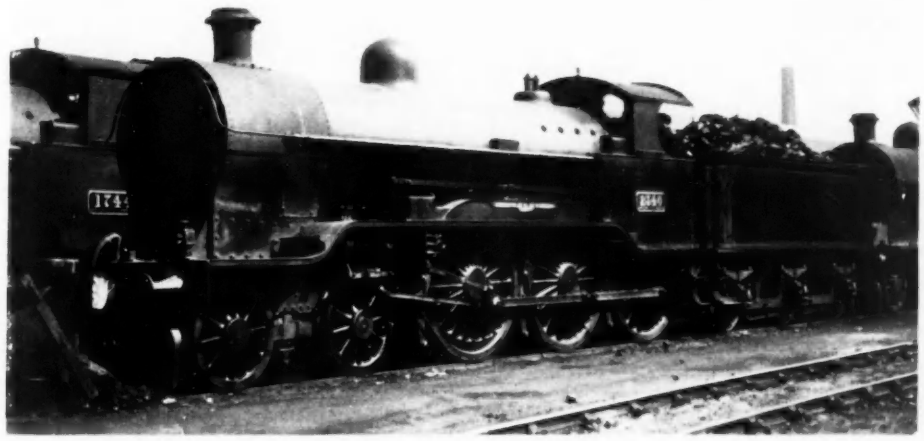


Combination piston valve for inside and outside cylinders on Dutch 4-6-0 locomotive.

locomotives fitted with Joy's gear led H. P. M. Beames, then Mechanical Engineer at Crewe, to fit outside Walschaerts gear to inside-cylinder 4-6-0 locomotives of the "Prince of Wales" class (shown below). The only divergence from the orthodox gear lay in the substitution of crank-pin drive to replace the movement normally derived from the crosshead. While this is believed to be the first use of an outside Walschaerts gear on an inside-cylinder engine with inside steam chests, there had previously been many applications of outside valve gear, e.g. Gooch and Stephenson, to locomotives having inside cylinders, with or without outside valve chests.



Southern Railway locomotive with J. T. Marshall's valve gear.



Application of outside Walschaerts valve gear to inside-cylinder locomotive.

Walschaerts gear had been fitted to engines on the Continent with inside cylinders and outside steam chests. In addition to the usual benefits to be derived from the use of an outside motion, there was also the improvement to the crank axle resulting from the removal of eccentrics with their objectionable rigidity.

The Stephenson-Molyneux system[84] was a Walschaerts gear with the combination lever arranged horizontally. This enabled the gear to be used between the frames with a comparatively free hand, for the valve chest could be above, below, or beside the cylinder and certain components of the gear could be arranged to operate in any desired plane. This gear, which despite its attractions had no wide application, was fitted to a three-cylinder 4-6-4T locomotive built by Robert Stephenson and Company, Limited, for the Buenos Aires and Pacific Railway.

In 1926 J. T. Marshall produced a gear having features in common with the Bonneford and Berthe gears used in France, in that provision was made for separate admission and exhaust valves. Whereas the former were arranged for expansive working, the latter had constant opening. As applied in Britain to a 2-6-0 locomotive (No. 1850) on the Southern Railway, the admission was at the top of the cylinder, and the exhaust valves, operated through a vertical rocking lever, were below the cylinder. This gear was certainly one of the most complicated ones to be used in Britain; though it was reported to show a steam saving, it was not sufficiently attractive mechanically to warrant retention.

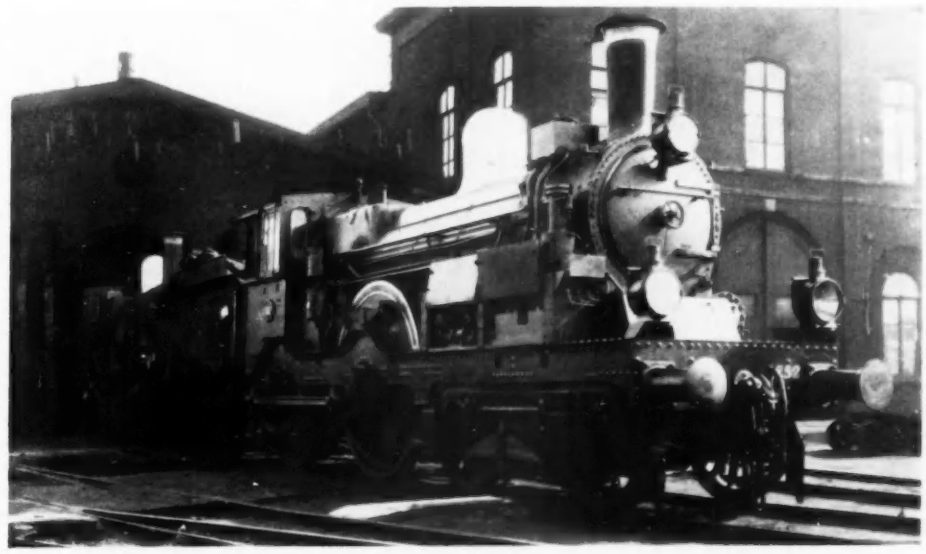
Valve gears which had a comparatively extensive use in America but never found employment in Britain were the Baker and Southern gears. In the Baker gear, introduced about 1912, the link was replaced by a crank-shaped rocker. No sliding surfaces were employed and as all connections were made by pins and bushes it was claimed that restoration to new condition was simply and inexpensively attained by rebushing and fitting new pins. This gear was wider than Walschaerts gear, which would have made it difficult to fit on some British locomotives.

The Southern gear, which was essentially the Strong type of gear reintroduced about 1917, bore considerable resemblance to a Walschaerts gear but had the link arranged horizontally. From the point of view of distribution this gear gave satisfactory results, but lack of lateral stability resulted in its not surviving.[85]

Probably the last example of hydraulic valve gear used on a locomotive was that on the Meier-Mattern system applied to Nos. 1752 (shown below) and 1777 of the Netherlands Railways in 1929.[86] It operated poppet valves and, while the results obtained on test were favourable, it was yet another of those cases where no lasting enthusiasm was displayed. Quick opening and closing were stated to be the great advantages of this gear.

It is considered unlikely that any further use will be made of conjugate gears, which accounts for their inclusion in this article. The possible exception is for narrow-gauge locomotives where restrictions of width rule out an independent valve gear between the frames, but in such instances some designers have used an outside gear whose duty is solely to impart motion to an inside cylinder via rocking or pendulum levers.

The idea of deriving motion for a third cylinder from two sets of gear originated with David Joy in 1884. The first practical application was to H. Holcroft's patent, as fitted to German locomotives, 1914-15, and later the idea had an extensive application in the Gresley gear used on the G.N.R., commencing in 1918, and later on the L.N.E.R. While the gear gave good results once its idiosyncracies were understood and when it was well maintained, it was particularly vulnerable to poor maintenance, for, unlike the Walschaerts gear where any inaccuracies are divided several times over by the movement of the combining lever, in the Gresley gear any slop, etc., is multiplied by the levers. Results accruing from this gear in certain circumstances were illustrated in B.T.C. Bulletin No. 8[87], which showed the unevenness of the steam distribution to the inside cylinder. This unevenness when most pronounced resulted in longitudinal oscillation of the tender drawbar, corresponding to a periodic variation in pull of 0·5 ton. It does not seem to be generally known that the Gresley gear was fitted by ALCO in America. These builders recommended a maximum speed of 35 m.p.h. on loco-



Dutch locomotive with hydraulically operated valve gear.

motives so equipped. Manufacture of the gear in the United States was discontinued on the grounds of inaccessibility.[88]

The conjugate gear fitted by W. Pickersgill of the Caledonian Railway to some three-cylinder 4-6-0 locomotives had no less than 14 pin joints and, in the words of Mr. E. S. Cox[89] " it ceases to be a practical proposition at all." The locomotives so fitted were notoriously unsuccessful.

Changes in cylinder position have largely influenced changes in valve gears, and generally outside cylinders have been accompanied by outside gears. Exceptions which will instantly occur to the reader were G.W.R. locomotives and Mr. O. V. S. Bulleid's " Pacifics." While in theory the Bulleid enclosed gear offered advantages, in practice the difficulties were sufficiently pronounced to lead to a rebuilding scheme in which the gear is not perpetuated. Apart from mechanical failures the distribution at times leaves a great deal to be desired, as evidenced by the indicator diagrams reproduced in B.T.C. Bulletin No. 10 relating to performance tests on a " Merchant Navy " class locomotive.

Limited cut-off was introduced to prevent drivers from working their engines at long and uneconomic cut-offs. It had its greatest application in America where probably about 1,000 locomotives were built with cut-off restricted to between 50 and 60 per cent.[90] On the credit side was more economic operation, but when one had assessed the factors on the debit side the conclusion was left that the greater expansion was dearly paid for. Naturally, there was some loss of flexibility, and to obtain the requisite tractive effort, with reduced cut-off, larger cylinders were required. Increased piston loading without increased adhesive weight, plus erratic crank effort, resulted in bad slipping and sometimes stalling. The system was out of favour in the United States by about 1930—by which time an engine was seldom constructed with less than 70 per cent. cut-off.[91]

To be continued

(The year quoted in the fourth line from the bottom of the second column on page 810 of the third article should have been 1879, not 1895.)

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[90] Bruce, A. W., *loc. cit.*, page 97
[91] *Ibid.*, page 98.

Book Reviews

DRAUGHTSMAN'S CRIB

The Drawing Office Handbook. Edited by R. W. STUART MITCHELL. Third edition. Published under the auspices of the Drawing Office Material Manufacturers and Dealers' Association by *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2.* (16*s.*)

To the average draughtsman the act of drawing is secondary. Except in the case of complicated castings, great drawing ability is not called for. In the presentation of information, however, a drawing becomes a device where exactitude is essential and this turns it into a unique document. The statements are facts with only one interpretation. The artist's drawing presents a picture as he sees it, interpreted by the viewer as he wishes. Lawyers are so obsessed by the fear of misinterpretation that they use a jargon that not only confuses the public, but very often themselves. In engineering this cannot be permitted. Having decided on the form of the article, the dimensions must be accurate, the material correct, and the method of manufacture understood, and all clearly stated.

The form is dictated by the design of the mechanism or its duty. Dimensions are decided partly by form and partly by unique physical peculiarities. Here a draughtsman can waste a lot of time searching for information he knows exists, without knowing just where to look. This of course varies with the experience of the individual, but nevertheless there is a constant demand in every engineering organisation, large or small, for that little bit of extra knowledge. How to deal with a slightly different problem in mechanics, with stress concentration, how to insulate vibration, and if one has to put up with vibration, how to find the material with the best fatigue properties. If welding is the answer, what is the type and will the physical properties be retained afterwards? The answer to these questions must appear on the drawing.

In these days of specialisation, one cannot hope to possess a working knowledge of every new method. As more and more detail information is gained, so the chances of any individual being in possession of it becomes less and less. The draughtsman is therefore driven to the use of books of reference, and the field to be covered is so vast that for an individual to possess a complete reference library is impossible. It comes to this then. A draughtsman needs a fund of accurate and concise information in such a form as will tell him what he wants to know or how to find it, preferably in one volume. This third edition of *The Drawing Office Handbook* does just this.

Many attempts have been made to supply the engineer with information in a concise form. None has quite understood the draughtsman's needs. There have been long chapters on pet subjects to the exclusion of more general things, or too many subjects have been included with too little explanation and practically no direction for finding expert advice. The new handbook gives a very clear precis of the subject and, where a deeper discussion is necessary, provides a list of references.

To quote just one instance—vibration. There is a brief study of the problems besetting the modern designer. Various types of vibration are dealt with in just sufficient detail to enable him to identify his particular problem. It is then up to him to choose which authority he will consult, and with such names as Ker Wilson, Morris, Timoshenko, etc., to guide him, he is in good hands. The same remarks apply to that mystery of mysteries—gearing. This chapter is particularly fascinating, showing again that gear design follows the normal laws of mechanics, without going into a welter of detail.

Other chapters are on mechanics and physics, and the formulae are given with great clarity. Very few draughtsmen remember every detail of their academic training. They only remember text-books as extremely trying devices designed to obscure the vital bit of information they need; for example, to calculate the bursting speed of a flywheel. The handbook gives us what we want, a clear indication that we are in the right department, and then a precise formula. To a mechanical engineer, the electrical and electronic sections are a little vague. Perhaps that does not matter a lot. The majority of draughtsmen are dealing with the mechanical aspects of these as well as other problems, and for that reason there is enough to put them on the right road to finding the answer. In Part II, for instance, there are the formulae for a most complete range of problems, from the stressing of struts, shafts and cylinders, to an exposition on stress concentration and the flow of gases and liquids in pipes.

The type face is pleasing, the layout excellent, and the charts very clear, with enough detail to satisfy the most exacting. Considering the importance of his work, the draughtsman's tool kit is singularly inexpensive. This handbook should become such a tool of his trade, and again the outlay is very modest. It would make an excellent present for a draughtsman of any age and a very attractive prize for the ace apprentice in those organisations where training schemes are in operation.

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COLLECTORS OF DUST

An Introduction to Electrostatic Precipitation in Theory and Practice. By H. E. ROSE and A. J. WOOD. *Constable and Company, Limited, 10 Orange-street, London, W.C.2.* (17*s.* 6*d.*)

Most schoolboys know that by vigorously brushing a small sheet of brown paper and holding it above a cat's back it is possible to cause the fur to stand on end, and even to draw crackly sparks of electricity from it. If the surface of the brown paper were examined under a microscope just before the spark discharge occurred, it would be seen that a thin layer of dust extracted from the animal's fur had been attracted to the paper. This has nothing whatever to do with feline attributes but is merely one of many examples in everyday life of the occurrence of static electricity; the most spectacular is, of course, the thunderstorm, and is there a mechanical or electrical engineer who has not had his problems in " static " on driving belts or in some works process ?

Long before electricity became the important factor it now is, scientists were investigating the peculiar qualities of " static," and the point which really intrigued a number of them was the attraction of dust or the agglomeration of smoke by an electrified stick of sealing wax or a piece of amber. Nothing of any importance developed until towards the end of the Nineteenth Century, when electrical knowledge and technique were becoming more clearly understood. The aspects of high voltage and requirements in insulation were being studied, and out of the welter of infinite possibilities in the new electrical age came the beginnings of electrostatic precipitation, a process of the utmost importance to everyone since it has been called upon to purify the air we must breathe.

The pulverised fuel system of boiler firing would certainly not have gained its present favour had it not been for electrostatic precipitation—the only means of separating efficiently the tiny particles of fly ash and dust from the effluent flue gases to the extent of millions of tons per year. The cement industry has sought the aid of precipitators in preventing the distribution of dust over the countryside, and

many industries have benefited by the recovery of dusts and fumes of intrinsic value, a value sometimes so high that the capital outlay on the plant has been recovered in less than a year's working.

It is a far cry from an electrified stick of sealing wax to the precipitator which treats millions of cubic feet of gas or air per hour, but there are thousands of electrostatic precipitators in operation, all over the world. In addition to the cleaning of effluent gases from heavy industries, the process is applicable to the intake air of ventilation systems where pure air, absolutely free from dust or bacteria, is required. The process could be applied to many buildings in the campaign for clean air.

Much has been written about electrostatic precipitation, but it has appeared mostly in the form of papers before technical societies and has dealt with certain aspects of the process in certain plants. Few writers have ventured on a concise or comprehensive book on the subject and it has been left to Dr. H. E. Rose and Mr. A. J. Wood to fill the gap with their volume *An Introduction to Electrostatic Precipitation in Theory and Practice.*

The authors disclaim that their work is a text-book or a design manual, but regard it as a survey of the existing knowledge of the subject. The theory of electrostatic precipitation is complex in the extreme and it is dealt with, in this book, in a highly commendable manner, but the more informative aspect is the practical side, for the obvious reason that there is complete inconstancy in dust types and compositions, and theoretical viewpoints, which include the laws of probability, can become quite valueless in consequence.

In view of this, it is noteworthy that many of the authors' observations are derived from practical experience and thereby acquire an added value. It is also to the authors' credit that a chapter is devoted to "precipitator problems" where candid admissions are made regarding "the inexplicable behaviour likely to be encountered in precipitator practice"; or that "no satisfactory explanation on the basis of existing theory can be given." An experienced operator would be fully aware of such occurrences and could invariably counter the former and not worry unduly over the latter.

As a "survey of existing published knowledge" the work is worthy of inclusion in the libraries of all engineers concerned with dust and fume removal. It is written in an interesting style which commands the reader's attention, but experience and "know-how" remain the stock-in-trade of the manufacturers.

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NEW BOOKS

Some of the books noticed here are selected for extended review in ENGINEERING.

Fixed Capacitors. Radio and Electronic Components: Vol. 3. By G. W. A. DUMMER. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2.* (45*s.*)

The author of this series of volumes is head of Components Research Development and Testing at the Ministry of Supply's Radar Research Establishment. Volumes 1 and 2 deal with fixed and variable resistors and Volume 4 with variable capacitors and trimmers. This volume on fixed capacitors describes the manufacture of the different types in some detail, together with the characteristics of the various di-electrics such as paper, mica, ceramics and glazes. An extensive bibliography is included, and nearly one-third of the book is given up to tables showing the characteristics of representative types of fixed capacitors as regards mechanical and electrical strengths and climatic suitability.

Friction and Lubrication. By F. P. BOWDEN and D. TABOR. *Methuen and Company, Limited, 36 Essex-street, London, W.C.2.* (10*s.* 6*d.*)

A brief account of modern work and views on the mechanism of friction and lubrication is given. The treatment is non-mathematical, and has been kept simple. Most of the work is based on researches carried out by the authors and their colleagues at Cambridge. Physical methods, including the use of radio-active tracers, of reflection electron microscopy, and electron diffraction, are used to investigate the nature of metal and other solid surfaces, and to determine the physical processes which operate when they come into contact or slide on one another. These observations have led to the development of low friction surfaces and bearing materials. The behaviour of lubricated surfaces is considered, both under fluid-lubrication and boundary-lubrication conditions. An account is given of the advances in understanding of the way in which lubricant films behave on metal surfaces and of recent progress in the development of special lubricants which will act effectively under severe conditions of high temperature and heavy load. A fuller account of work in this field is given in the authors' book, *The Friction and Lubrication of Solids*, 1954, Clarendon Press, Oxford.

Oil Fuel Applications. By A. T. HENLY. *Crosby Lockwood and Son, Limited, 26 Old Brompton-road, London, S.W.7.* (35*s.*)

After an introductory section on oil and its standards, the author proceeds to deal with oil storage problems, pipe lines and heating of storage tanks. These are followed by sections on oil-burning systems, ancillary equipment and automatic controls. Specialised applications are included and, in particular, there is a chapter on waste-heat recovery from the Diesel engine. A large number of present-day British oil-fired plants are described. The range includes both domestic and industrial applications.

The Clean Air Act, 1956. By PETER C. G. ISAAC. Department of Civil Engineering, Bulletin No. 8. *Public Health Engineering Laboratory, King's College, Newcastle-upon-Tyne.* (5*s.*)

This is the text of a lecture that was given during a refresher course on smoke abatement and atmospheric pollution. The series of lectures of which this formed part, concerned the necessary technical development required for the reduction of air pollution. At the end there is an appendix giving some extracts from American legislation.

Basic Electricity. Laboratory Manual for Radio and Television Technicians. By PAUL B. ZBAR and SID SCHILDKRAUT. *McGraw-Hill Book Company, Incorporated, 330 West 42nd-street, New York 36, N.Y., U.S.A.* (1.75 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (13*s.*)

Published by the Radio-Electronics-Television Manufacturers' Association, this book consists of a series of 27 "jobs" each with such objects as "to determine experimentally the reactance of a capacitor" or "to determine the turns ratio of a given transformer." In each case the materials required are listed, introductory information given, and the procedure of the test laid down. At the end of each are a few questions to ensure that the job has been understood. As its title implies the material is somewhat elementary in its scope, but could form quite a useful foundation for a technician.

Power System Stability. Vol. III: Synchronous Machines. By EDWARD WILSON KIMBARK. *John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York 16, N.Y., U.S.A.* (10 dols.); and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (80*s.*)

In this series, volume I dealt with elements of stability calculations and volume II with circuit breakers and protective relays. In volume III the particular sections are devoted to synchronous machines, excitation systems and damping. The last section on steady state stability extends the brief remarks on this subject made in volume I. Worked examples are included in the text, and each section ends with references and revision problems.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Machine Tool Lubrication. C. C. WAKEFIELD AND CO. LTD., 67 Grosvenor-street, London, W.1. This is a technical treatise on the subject of machine tool lubrication. It starts with an examination of the fundamentals of friction and lubrication, and proceeds to a consideration of the general design features of machine tools. The construction, operation and lubrication of the basic machines are then reviewed, chapters being devoted to lathes, drilling, milling, planing, shaping and slotting, broaching and grinding machines. Other types of machines such as power presses, gear machines and fine-finishing equipment are the subjects of further chapters. A scheme for factory lubrication is also described. Book of 96 pages, in stiff binding, with many illustrations in line and half-tone.

Spheroidal-Graphite Iron. S. RUSSELL & SONS, LTD., Bath-lane, Leicester. Data on the mechanical and physical properties of the firm's C, D, E, and F grades S.G. iron in relation to the types contained in the newly-issued British Standard 2789: 1956 for iron castings with spheroidal or nodular graphite. Many illustrations and brief descriptions of typical applications are included. Booklet.

Oscillating Hoists. MARTONAIR LTD., Parkshot, Richmond, Surrey. Overhaul trolley hoists for oscillating components in brine baths, degreasers, wash tanks and the like. Pneumatic operation giving movement of 1 ft. at 30 oscillations per minute. Five sizes with maximum load of 500 lb. and maximum hoist of 10 ft. Leaflet.

Epoxy Jigs and Tools. AERO RESEARCH LTD., Duxford, Cambridge. Araldite synthetic resin for steam and electrically heated jigs, platens with low-voltage and stray-field heating elements, woodworking tools, router jigs. Descriptive pamphlet, Aero Research Technical Notes Bulletin No. 166, Oct. 1956.

Tank Heating Coils. COLVIN-SMITH LTD., Riverside Works, Southshore-road, Gateshead-on-Tyne 8. Cast-iron and aluminium-brass heating coils for marine and land applications, specialised pipework, Hi-Pres air-conditioning systems. New factory, recently officially opened, now in full production. Descriptive leaflets.

High Temperature Pumps. RHODES, BRYDON AND YOUATT, LTD., Waterloo Engineering Works, Gorsey Mount-street, Stockport. Vertical high-temperature "Mopumps" of "350" series for pressures up to 300 lb. per sq. in. Six models up to 7 in. discharge bore. Publication No. 1506.

Carving and Lettering Tools. CLIMAX ROCK DRILL AND ENGINEERING WORKS, LTD., Carn Brea, Redruth, Cornwall. Pneumatic carving and lettering tools for stone workers. Seven sizes; can also be used for paint scraping, scaling, etc. Leaflet No. 194.

Air Compressors. B.E.N. PATENTS LTD., High Wycombe, Buckinghamshire. 1·25 cub. ft. 50 lb. per sq. in. compressor for beer lifting, etc.; Tracdrive 35 cub. ft. 100 lb. per sq. in. mobile tractor-mounted compressor. Separate illustrated leaflets.

P.V.C. Fans. MATTHEWS & YATES LTD., Cyclone Works, Swinton, Manchester. Turbro-Cyclone P.V.C. fans for chemical fumes, corrosive gases and laboratory ventilation. In capacities from 100 cub. ft. to 5,500 cub. ft. per minute. Descriptive and specification leaflet, illustrated.

Pipe-Line Fittings. WOODFIELD HOIST AND ASSOCIATED INDUSTRIES LTD., Frindsbury Works, Rochester, Kent. Pipe line fittings for pressures up to 7,500 lb. per sq. in. including unions, blanking plugs, swivel joints and collar clamps. Booklet.

"Train at Timken." BRITISH TIMKEN LTD., Duston, Northampton. Illustrated brochure describing the work at British Timken and the various training schemes in force. Available to educational and personnel officers.

Rotary and Band Screens. F. W. BRACKETT & CO. LTD., Hythe Bridge Ironworks, Colchester. Rotary and band screens for filtering liquids. Mesh $\frac{3}{16}$ in. sq. and upwards. Brochure No. 1050 describes types and No. 1025 lists users.

Walking Draglines. RANSOMES AND RAPIER LTD., Ipswich. Walking dragline with bucket capacities ranging from $1\frac{1}{2}$ cub. yards to 20 cub. yards; machine weights from 108 tons to 1,650 tons. Illustrated leaflet.

Soil Mechanics Testing Equipment. SOILTEST, INC., 4711 W. North-avenue, Chicago 39, Illinois, U.S.A. Engineering testing apparatus for soils, asphalts and concretes; both laboratory and field equipment. Catalogue.

Plant Hire. BROWN AND TAWSE PLANT LTD., Ambrose-street, West Gorton, Manchester, 12. Portable air compressors, excavators, rollers, concrete mixers, drilling equipment, etc. Illustrated leaflets.

Cranes. RANSOMES AND RAPIER LTD., Ipswich. "414" excavator with $\frac{3}{4}$ cub. yard bucket; alternative booms for dragline, grab, crane and pile driver. Illustrated leaflet.

Aluminium Paint. NORTHERN ALUMINIUM CO. LTD., Banbury, Oxfordshire. "Noral Alpaste" available in eight different grades. Pigment chart.

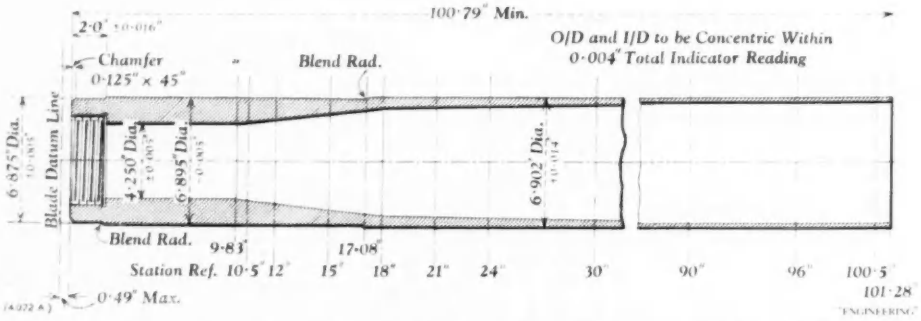

Fig. 1 Steel tube for aircraft propeller, produced by cold drawing from a machined hollow blank.

Station	$\frac{I}{D}$ + 0·002	Station	$\frac{I}{D}$ + 0·002
In.	In.	In.	In.
10·5	4·400	54	6·733
12	4·736	60	6·767
15	5·407	66	6·801
18	6·079	72	6·835
21	6·145	78	6·835
24	6·211	84	6·835
30	6·373	90	6·835
36	6·535	96	6·835
40·5	6·656	100·5	6·835
42	6·665	101·28	6·835
48	6·699		

TUBES AS RAW MATERIAL

COMPLEX SHAPES BY PRECISION COLD DRAWING

The finished products of many industries are the raw materials of many others, and the tube is no exception, for its uses are legion, extending as it does to applications far removed from the original one of conveying fluids. As a basis for the manufacture of countless components the tube is too well known to call for comment, but tube-making technique has developed to such an extent that it is not generally realised how many complicated and precise operations are possible in the tube works. Tubes can be produced to-day which are far from the original conception of a simple, round article of uniform wall thickness. They can be made to very precise limits, both dimensionally and in concentricity of inside and outside diameters, and the wall thickness can be varied to suit the requirements of the user.

The cold drawing process, which is used to produce precision tubes, is usually based on a rough tube or "hollow" made by hot-working from a billet, but there are occasions when the hollow is best if bored from the solid by ordinary machining. A tube 101 in. long, being made by Accles and Pollock, Limited, Oldbury, Birmingham, to the requirements of de Havilland Propellers, Limited, Hatfield, Hertfordshire, is an example of what can be done by cold drawing a bored-and-turned hollow. This particular tube, which is the main member of an all-steel propeller blade is, of course, made to the specific requirements of the customer, but the technique used in its production, or modifications of it, could be applied to any other tube of similar design. From the point of view of the tube user the principal features of the tube described here are: the inside and outside diameters are not constant for the whole length of the tube, the tapers joining the different parallel lengths of wall are not constant, but comprise several taper rates. In addition, the physical dimensions and metallurgical properties of the tube are very closely controlled. The dimensions of the tube are given in the table accompanying the drawing, Fig. 1.

MAKING THE HOLLOW BLANK

In this instance, as already mentioned, the tube is made from a machined-and-bored blank instead of a hot-forged hollow, the reason being that the metallurgical properties of the finished tube walls are subject to a very strict specification. By boring from the solid, any non-metallic inclusions in the metal, which tend to stay in the centre of the bar, are removed during the machining swarf, leaving the tube walls clear.

The production of the hollow blank, which was undertaken by Keeton, Sons and Company, Limited, Attercliffe, Sheffield, 4, commenced with hot-forged steel bars 7⅞ in. in diameter and 41 in. long, the steel being to a de Havilland specification which is similar to EN24. The bars are machined, bored, and polished all over, both the internal and external diameters having two parallel lengths of different diameters joined by a single taper. The overall length of the finished hollow blank is 40½ in. Diameters are specified in decimal parts of an inch, but the approximate figures are: internal 4¼ in. parallel for 9⅜ in., taper for 10¾ in., 6⅝ in. parallel for

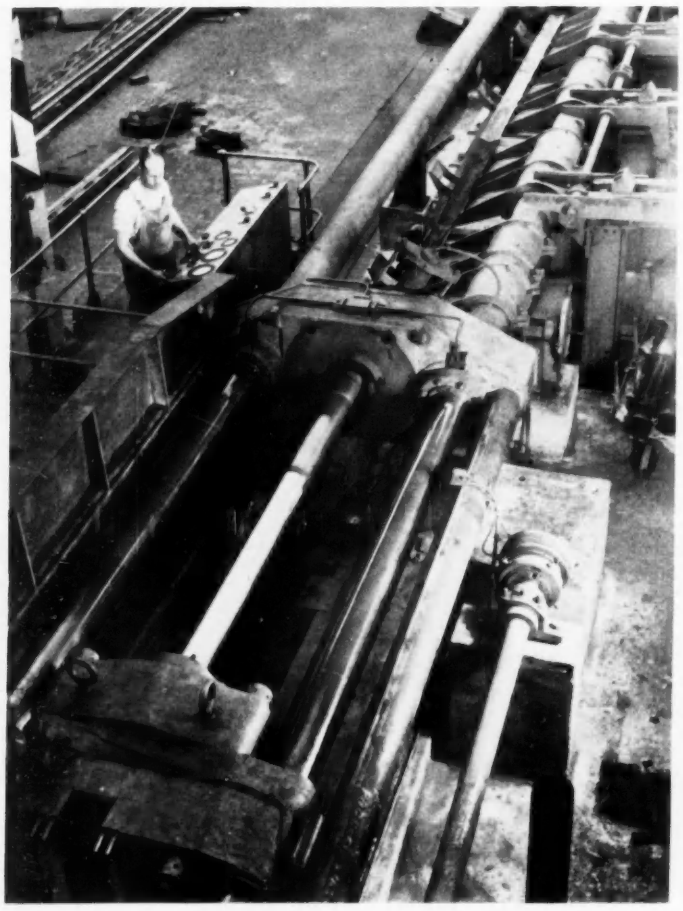

Fig. 2 Hydraulic draw bench used in the initial stages of drawing.

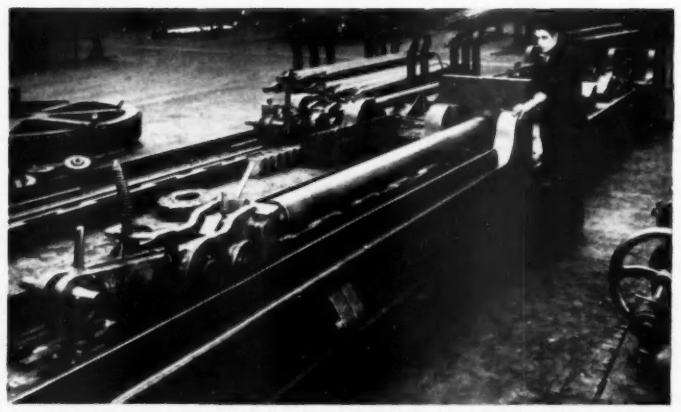

Fig. 3 Final drawing is done on a chain draw bench, to produce a tube of different sections throughout its length.

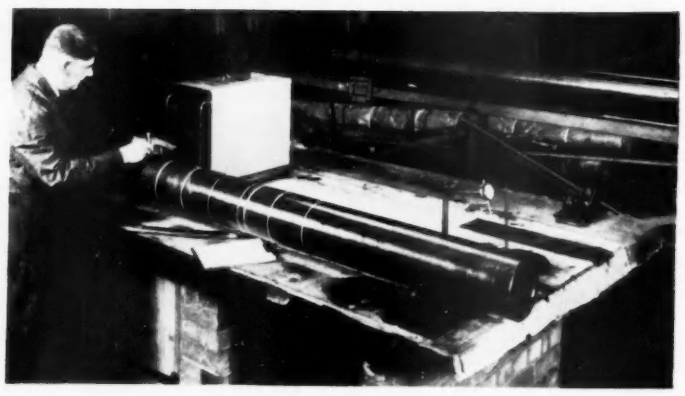

Fig. 4 There is a very rigid inspection procedure. This shows wall-thickness measurement with a Dawe "Visigauge."

20 7/16 in. Externally the blank is approximately 6 7/8 in. in diameter parallel for 16 3/8 in., taper for 3½ in., and 7½ in. in diameter parallel for 20 7/16 in. An internal screw thread is cut in the thick-walled end of the blank for manufacturing purposes; this threaded portion is eventually cut off.

The hollow blanks pass through 180 operations in the works of Accles and Pollock, Limited, and are extended some 4½ times in length in the course of cold drawing. The drawing involves the use of hard chrome-plated drawing dies and mandrels, made from special steels, coupled with special drawing techniques. Inspection exercises a very rigid control over the tube at all stages during its manufacture. The accuracy of the finished tube is such that the diameter, including ovality, does not vary more than 0·060 at any point, the total eccentricity does not exceed 3 per cent., and the straightness is within ½ in. by surface-table measurement.

INITIAL COLD DRAWING

The machined hollow blanks are first de-magnetised, as a safeguard against possible interference with aircraft compasses, and then honed in the bore in vertical honing machines to obtain the standard of bore finish required in the finished component. A close dimensional check is then made of the blanks; this is the first of many dimensional checks, which follow the progress of the blank through the subsequent drawing operations.

The first cold-drawing passes are made on a horizontal hydraulic draw bench, which is shown in Fig. 2. The drawing does not involve " tagging " the end of the tube and drawing it through the die; instead, a plug is screwed into the threaded portion of the thick-walled end of the tube, and this plug takes the load as the mandrel is pushed through the die, taking the tube with it. The draw bench is a normal item of equipment in the shop, and is used for other work as required.

Between each successive drawing operation the tube is annealed. This is done in a sealed pot, which is continuously purged throughout the heating and cooling period with dry nitrogen gas, fed at a pressure of 4 in. water gauge. Nitrogen is obtained from town gas, cracked in a high-nitrogen plant, and passed through alumina driers. The tube emerges from the pot after annealing with a bright, scale-free surface, and no further treatment is necessary to prepare it for the next drawing pass, except lubrication, which is done by immersion in a tank of lubricant.

FINAL DRAWING

The finishing passes in the cold-drawing process are given on a chain draw bench (Fig. 3). When the tube is drawn to size an inspection follows while it is still on the mandrel. It is then given a light reeling, in order to break the contact between the tube wall and the mandrel, and returned to the chain draw bench, where the mandrel is withdrawn. This is done by anchoring the tube to the bench by means of its screwed end and an anchor bar, and pulling the mandrel out with the carriage and dog. It is of particular interest that the tube, as it leaves the mandrel, is ready for final inspection; no sizing operation is needed, a fact which perhaps more than any other demonstrates the advances made in tube-drawing technique in recent years. It is, of course, a reflection of the care used throughout the process, and the skill of both operators and designers.

The methods and equipment used in inspection, both during processing and of the final product, ensure that every tube meets the specification in full. Outside diameters are measured in the normal way, by micrometer, dimensions being taken at set intervals along the length of the tube, as laid down in the inspection procedure. Wall thicknesses are also taken at set intervals, by means of a Dawe " Visigauge " (Fig. 4). Visual examination of the bore is carried out at several stages in the manufacture with the assistance of an electric light at one end of the tube. Final visual examination is made with a Foster " Introscope," the tube being laid on a simple carriage so that the operator can move it as required.

HIGH-CONDUCTIVITY COPPER ALLOYS

Materials which have achieved considerable importance in the electrical industries and in applications involving the transfer of heat are the four alloys of copper containing, respectively, cadmium, chromium, silver and tellurium. Silver, in amounts averaging 0·08 per cent., has no appreciable effect on the conductivity of copper, but the other three elements decrease it slightly. On the other hand, they impart other desirable properties, to gain which some degree of conductivity can be legitimately sacrificed. In particular, cadmium and chromium impart increased strength and resistance to wear, while tellurium improves the machinability. All four elements increase the temperature at which copper anneals and softens, and silver is added specifically for this purpose. The fields in which these qualities can be employed to advantage are numerous and varied and these and the alloys themselves are described in detail in a new 54 page publication, entitled " High-Conductivity Copper Alloys," just issued by the Copper Development Association at their new address: 55 South Audley-street, London, W.1.

Copper containing between 0·7 and 1·0 per cent. of cadmium possesses greater strength under both static and alternating stresses, as well as better resistance to wear, than ordinary copper. The improved mechanical properties are especially pronounced in the cold-worked condition and hard-drawn cadmium copper is particularly suitable for the contact wires of electric railways, tramways, trolleybuses and gantry cranes and for Post Office line wires and overhead power lines of long span. Cadmium copper, moreover, retains the hardness and strength imparted by cold work at temperatures well above those at which high-conductivity copper softens. The alloy is therefore used in the manufacture of electrode holders for resistance welding machines and arc furnaces, electrodes for the spot and seam welding of steel and other alloys and for the commutator bars of certain types of electric motors. The high elastic limit of the material in the work-hardened condition makes it also suitable for the manufacture of small springs required to carry electric current.

Copper containing less than 1 per cent. of chromium forms a precipitation-hardening alloy which is specially suitable for applications in which considerably higher strength than that of copper is required in conjunction with high electrical and thermal conductivity. Two of the chief specific applications are for welding electrodes, of both the spot and the seam types, and for the cylinder heads of internal combustion engines, especially for aircraft.

The principal uses of silver copper are in connection with electrical machines which either run at somewhat elevated temperatures or are exposed to them during manufacture, as for example where soft soldering or the stoving of insulating materials has to be applied. For the same reason, it is favoured for motor-car radiators or other heat exchangers which have to be soft soldered, and for photogravure printing plates requiring to be heated for the " burning-in " of gelatine.

Tellurium copper containing from 0·3 to 0·7 per cent. of tellurium may be employed in all cases in which speed and precision of machining are necessary in the production of articles, the electrical or thermal conductivity of which must remain high. A classical example is the production of magnetron bodies, which in many cases are machined from solid blocks of high-conductivity copper. The cutting of a complicated arrangement of slots or holes of high dimensional accuracy is greatly facilitated by the adoption of tellurium copper. The material is also used to replace free-cutting brass for screwed pipe unions and similar fittings in corrosive environments. Tellurium copper is not subject to the type of corrosion known as dezincification.

HEAVY-DUTY FLOOR COATING

Claimed to be an entirely new type of heavy-duty liquid floor coating for industrial purposes, Exon, a preparation consisting of a polyvinyl base emulsified in water, has now been introduced commercially by " Exsud " South American Minerals and Products Company, Limited, 26-27 Cowcross-street, London, E.C.1.

The preparation is not just a floor paint; penetration into concrete, stone and similar surfaces is said to take place, as a result of which the hardness and resistance to abrasion of the treated surface is increased and the surface disintegration of the concrete is impeded, thus preventing the creation of dust. The product resists both acids and alkalis in moderate strength.

No solvents are required with the material, which is thinned when necessary, as when used for spray application, with water. Treated floors are quickly ready for service; in normal weather conditions a coating is finger dry in 30 minutes, can be walked on after three hours and is ready for all traffic and heavy weights after 24 hours. The coverage for a first coat of one gallon of the preparation ranges from 70 to 80 square yards on smooth, relatively non-porous surfaces, to 20 to 25 square yards on rough, porous material.

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CAR DESIGNS AND ROAD INJURIES

In the United States, the annual slaughter on the roads is as big a problem as in this country. The fact, however, that 75 per cent. of the fatal accidents on the roads occur to the occupants of motor vehicles (the corresponding figure in Britain is about 17 per cent.) has led to a certain amount of research into injuries sustained in road accidents. The Department of Scientific and Industrial Research has summarised this research work in the United States in Road Research Technical Paper No. 37.

From a number of different sample investigations in which the road conditions varied rather considerably, the following main points seem to emerge. On impact in a crash, one or both front doors open in a high proportion of cases, resulting in an increased possibility of fatal injury. A certain amount of useful information has been obtained as to which type of door is likely to open most readily depending on the nature and place of the impact. The main internal features of a vehicle causing accidents to occupants were found to be instrument panels, steering components, windscreen glass or frame, and door components in that order, but the part played by speed in fatal crashes has not yet been isolated. The results obtained so far do emphasise the important part played by car doors and internal fitments to vehicles. Broad corroboration of the data provided by accidents has come from experiments with dummies.

Some work has been done in this country on vehicle accidents but here, of course, the fatal rate among pedestrians, pedal cyclists and motor cyclists is higher than in the United States. Since speeds, the weights of cars, the composition of traffic and the driving conventions vary considerably between the two countries, the American data would not provide a satisfactory basis for any firm conclusions about traffic accident fatalities in this country. It is likely that a thorough investigation in the United Kingdom would show the same high proportion of serious accidents to head, chest and limbs as in America, but the very much lower proportion of fatal accidents to the occupants of vehicles over here makes it much less likely that serious pressure can be put upon car manufacturers to introduce safety devices such as safety belts and chest pads on steering wheels. It may happen, however, that vehicle designers in the United States will be encouraged to place greater importance on safety measures and this, in time, would affect vehicles in this country for many of the best-sellers are American inspired.

CHEMICAL MILLING

COMPONENTS FROM SHEET BY ETCHING

We give below an abridged version of the paper "Contour Etching" given by Mr. A. W. Sheppard, production engineer to Saunders-Roe Limited, at the fifth conference on Problems of Aircraft Production, the report of which commences opposite.

The introduction of the chemical-milling or contour-etching process resulted from difficulties encountered in forming sheet to the required contours after machining; with contour etching it is now possible to form sheet to the necessary shape and then to etch or mill the geometric reliefs dictated by design requirements. The process has other virtues such as a considerable economy in machine-tool requirements; a saving in weight which designers have been quick to exploit; elimination of a large number of detail tools; and simplified paper work control of a job.

The process, basically of four stages, is as follows: (i) pre-treatment cleaning of material; (ii) the application of the resistance medium (known as "masking"); (iii) etching; and (iv) post-treatment—neutralising and cleaning.

Pre-treatment entails degreasing and pickling to give a chemically clean surface which is also suitably receptive for the "resist," and is carried out by degreasing in trichlorethylene vapour for 20 minutes followed by pickling in a chromic-sulphuric acid solution for a further 20 minutes. After this, the component is water-washed for 10 minutes in both cold and hot water.

Prior to applying the resist, as the resistance medium is usually known, the component must first be covered on the surface to be worked with a strippable coating over which is placed a stencil defining the contour of the area to be etched. A knife is then traced around the periphery of the stencil to cut the strippable coating which is peeled off in the areas where etching is not required. The component is next sprayed with a standard aircraft etch primer to ensure complete adhesion of the resist, after which it is stoved for 15 minutes to remove the solvents.

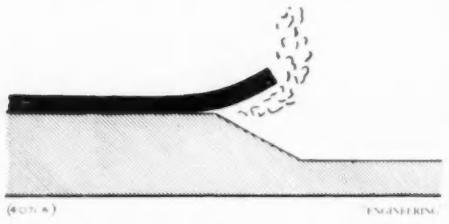


Fig. 1 Defective resistant coating being lifted off the surface of the sheet due to poor adhesion, or due to stiffness of the resist resulting in flapping causing peeling.

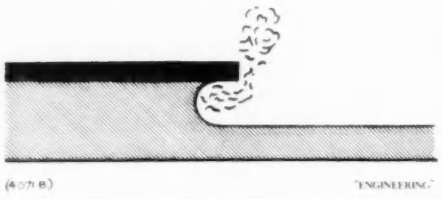


Fig. 2 Resistant coating too stiff, causing gas trapping, and so inhibiting etching.

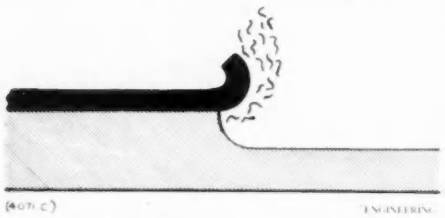


Fig. 3 Correctly formulated resist giving controlled radius at edge.

The component is now ready for the application of the resist—a polyamide-cured epoxy surface coating which is sufficiently flexible to allow the gases produced during etching to escape. Examples of edges produced by badly formulated resists are shown in Figs. 1 and 2; Fig. 3 shows a good edge.

After spraying on the resist the item is stoved in an oven for 30 minutes at 120 deg. C., or, alternatively, by infra-red lamps. Finally, the strippable coating is removed, thus exposing the areas to be etched.

Etching is carried out by placing the component in a hot alkaline solution for a specified time to remove the metal in the unmasked areas. The bath is a 12 per cent. sodium hydroxide solution modified by bringing the aluminium content of the solution to 2·5 per cent. and seeding with aluminium oxide, to give a constant etch rate of 0·045 in. per hour at a fixed temperature of 80 deg. C. The reaction between the sodium hydroxide and the aluminium may be represented by the following equation:—

$$2NaOH + 2Al + 2H_2O \rightarrow 2NaAlO_2 + 3H_2$$

The sodium aluminate, which has a depressing effect on the etch rate, is converted to alumina. This is precipitated and removed as a sludge by centrifuging — sodium hydroxide being regenerated, thus a constant etch rate is achieved. The hydrogen generated during the reaction should be removed by venting. Fig. 4 shows the behaviour of new etching solutions of various strengths in the unmodified condition, which emphasises the importance of temperature control and shows the etch rate.

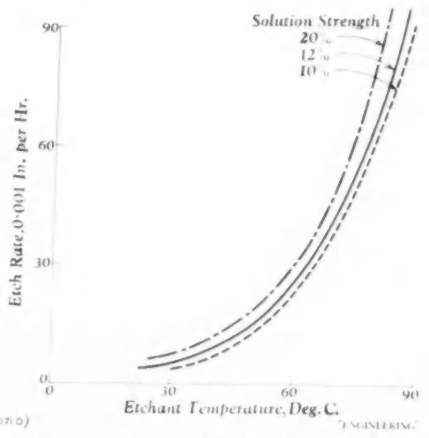


Fig. 4 Variation of etch rate with temperature in new etching solutions of various strengths in the unmodified condition.

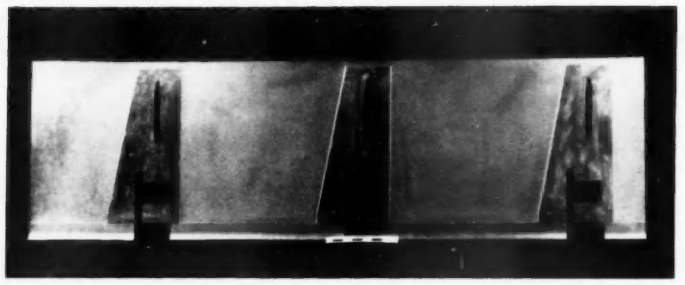


Fig. 5 Panel of varying depth, contour-etched in 6 hours.

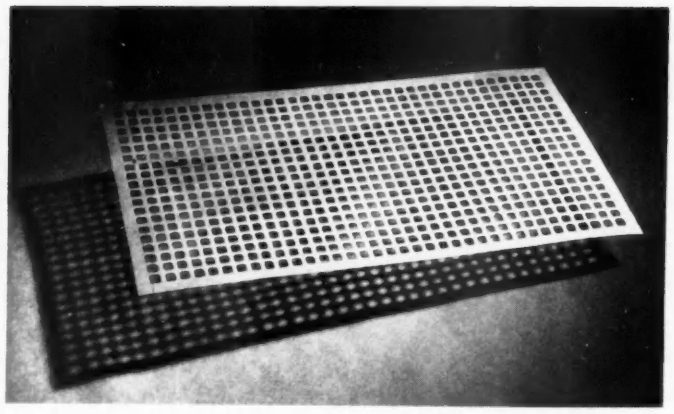


Fig. 6 A plate 0·006 in. thick etched to form a grille.

Post-treatment involves a cold water wash for five minutes, followed by immersion of the component in a cold 10 to 30 per cent. nitric acid solution for five minutes to remove the "smuts" and to neutralise. A further water wash, entailing a cold and hot rinse for 10 minutes, is followed by the final operation of removing the resistant coating by submerging the component in a suitable paint remover for 10 minutes.

The component should then be washed for five minutes, dried, and surface-protected as for a machined item, i.e., anodised or lanoline coated.

The surface finish is inspected against master samples which have been approved by the design and inspection authorities. These samples are in two grades: Grade 1, the equivalent of the finish produced on an age-hardened plate and free from blemishes; this finish is only insisted on where the fatigue life is of paramount importance. Grade 2 finish is similar to that obtained by etching plate in the solution-treated condition and is the minimum standard which can be accepted.

Fig. 5 illustrates a panel with varying depths which it would be impracticable to machine, as 75 per cent. of the skin is only 0·01 in. thick, with a leading edge of 0·036 in. from the original plate of 0·064 in. To produce this by contour etching took 6 hours. Redux-bonding, a possible alternative method, would take approximately 9 hours and would involve the cost of a bonding fixture and tooling for the detail parts as opposed to the cost of masking, plus an 18G stencil template.

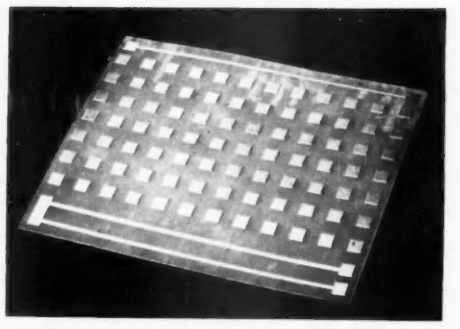


Fig. 7 Plate bonded to a glass-fibre laminate and then etched away to the required pattern.

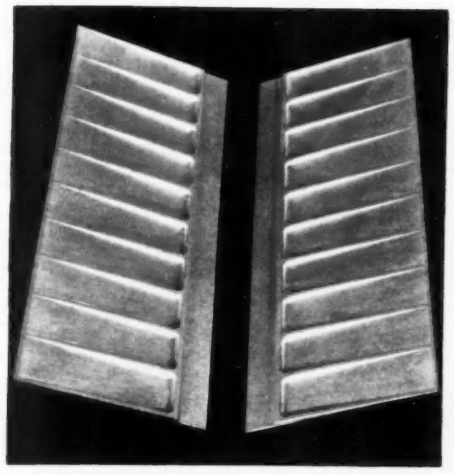


Fig. 8 Two integrally stiffened skins prior to bonding.

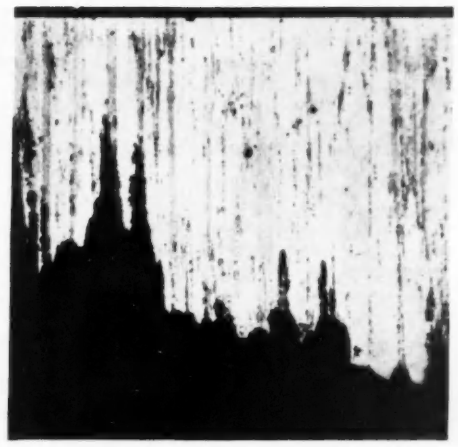


Fig. 9 Section through an L65 block etched to a depth of 1 in.; very small stress-corrosion cracks are apparent in one or two of the fissures.

TABLE I.—Bending Fatigue Tests on Flat Specimens of L71 Material Stressed to ± 24,000 lb. per sq. in.

Specimen No.	A Unmachined		B Machined		C Contour etched		D Contour etched and vapour blasted	
	Thickness, in.	Cycles to failure	Thickness, in.	Cycles to failure	Thickness, in.	Cycles to failure	Thickness, in.	Cycles to failure
1	0·126		0·085	223,600	0·085	229,800	0·084	351,300
2	0·127	417,700	0·085	370,100	0·084	180,500	0·084	270,000
3	0·127	775,700	0·085	222,400	0·084	228,300	0·083	208,500
4	0·127	360,000	0·085	254,800	0·085	221,700	0·083	620,500
5	0·127	330,900	0·085	133,900	0·084	201,900		200,300
6	0·127	309,900	0·085	178,800	0·085	171,900		

Fig. 6 depicts a 0·006 in. thick plate etched to form a grille, which would entail the manufacture of expensive piercing tools but which, by chemical methods, can be produced quite economically. Fig. 7 is a plate bonded to a fibre glass laminate and then etched away to the required pattern.

Taper milling by chemical means is done by gradual immersion or withdrawal at a predetermined rate from the etching solution. Fig. 8 shows two integrally stiffened skins, with tapered stiffeners and spar member, prior to bonding, the skin thickness being 0·01 in. The stiffeners are required to be of parallel section in plan view. This was achieved by first tapering the plate, then reversing the direction of entry and tapering the pockets after remasking.

PHYSICAL AND MECHANICAL EFFECTS

Materials which are age-hardened give a much finer surface finish than those in the solution-treated condition, probably due to the greater rate of differential attack on the softer material; Also the finish on the copper-containing alloys is superior to that obtained on those containing a high percentage of zinc such as DTD687, owing to the zinc being more susceptible to attack by sodium hydroxide.

Examination at high magnifications has revealed that, in materials to specifications such as L72, L73, and DTD687 reduced in thickness by contour etching using the sodium hydroxide solution, there is no inter-granular attack or modification to the structure below the etched surface. With L65 it was found that the deeper the etching was taken, the more the pitting increased in the direction of the end grain; Fig. 9 shows a section through an L65 block etched to a depth of 1 in. It can be seen that, although the majority of the fissures have the rounded bottom of chemical attack, there are signs of stress-corrosion cracks in one or two. This, of course, would affect the fatigue life of a component but, as the cracks are only of the order of 0·030 in. deep, they could possibly be polished out.

Bending fatigue tests are being carried out on specimens of materials in the "as received," machined, and contour-etched conditions, and the indications are that the number of loading cycles to failure of specimens produced by contour etching is of the same order as that for machined specimens. Table I shows the initial fatigue tests carried out on L71 material. All the specimens, except one, were tested at a stress level of ± 24,000 lb. per sq. in. and gave cycles to failure as shown.

NEW PRODUCTION METHODS

AIRCRAFT MANUFACTURING TECHNIQUES

"New Materials—New Methods" was the theme under which the fifth conference on "Problems of Aircraft Production" was convened by the Institution of Production Engineers, and held recently at Southampton University. In fact, new materials were barely touched upon, only one paper dealing with the forming of a metal—wrought magnesium alloy—which is not in common usage in the British aircraft industry; but which even so can hardly be considered as a new material since it has been widely used in American aircraft construction now for many years. A secondary theme which emerged, and which has been heard before, is the greater readiness of the American industry to take advantage of new processes and equipment such as the numerical control of machine tools, the hot-forming of magnesium alloys, the spot-welding of primary aircraft structure, and chemical milling—the subjects of four of the five papers which were the basis of the conference discussions.

AIRCRAFT FATIGUE

After the presentation of the Lord Sempill paper, which falls outside the theme of the conference but is discussed in this week's leader, the discussion was opened by Major P. L. Teed, deputy chief of aeronautical research and development to Vickers-Armstrongs (Aircraft) Limited, on "The Fatigue of Aircraft"—a subject which also lies not strictly within the main theme but which is, perhaps, linked with "New Materials" in that it is the new alloys of some ten years ago, the high-strength but highly notch-sensitive aluminium-zinc-copper-manganese alloys, that have brought the latent aircraft fatigue problem into prominence.

Major Teed's standpoint was that the resistance of a component to repeated stress is influenced by its surface condition, its residual stress, the stresses built into it on assembly, and the macro- and micro-structure of the material. The production engineer has some degree of control over some of these factors, such as surface finish and the built-in stress on assembly; he should, Major Teed thinks, face up to the problem of fitting oversize parts in order to ensure that these built-in stresses are compressive rather than tensile. Although in many cases the fatigue resistance of a component may be improved by imparting surface compressive residual stress by heat treatment, it is not always possible to exploit this advantage since, in asymmetrical components, distortion may result from the quenching treatment and the subsequent straightening operation may cancel out any benefit to fatigue resistance derived from the heat treatment.

Major Teed also discussed briefly the effect of grain size and inclusions on the fatigue strength of non-ferrous metal alloys; and, in his paper, he called attention to the fact that airframe stress concentrations may increase during the lifetime of an aircraft as a result of the corrosive environment, both inside and outside, in which the structure is working.

NUMERICAL CONTROL OF MACHINE TOOLS

In America to-day, the United States Air Force will not place orders for large machine tools such as skin millers unless they are fitted with electronic numerical control. Already many numerically-controlled skin millers and other large machines are on order for the American industry. To stimulate the interest of the British aircraft industry, Mr. O. S. Puckle, chief lecturer of E.M.I. Electronics, Limited, expounded the advantages and principles of "Numerical Control of Machine Tools in Aircraft Manufacture."

With this system, the machine tool is given instructions, in the form of numbers, for the motion of the slides and the cutting head. Complicated parts can thereby be made more quickly, more accurately and more cheaply. Numerical control, however, demands a higher standard in the design and construction of the machine tool, because every slide must be able to move simultaneously and hysteresis must therefore be reduced to a minimum. Progressive machine-tool makers are therefore devoting much attention to perfecting the fit of all moving parts and to reducing elastic deformation both in the moving parts and in the machine framework.

The art and science of programming—of translating the information on the drawing into coded numerical instructions on tape or punched cards—is still in its infancy. Four stages are involved: firstly, reducing the drawing to a standard form; secondly, breaking down the profile into short sections which—in the EMI analogue system—can be adequately represented by parabolas; the amount of human effort involved at this stage depends on whether or not a large computer is available to deal with it; thirdly, assessing factors based on experience such as the desired feed rate, the effect of feed rate on tool deflection, the amount by which a blending radius centre should be displaced to counteract the tendency of the cutter to dwell, the effect of the work material on the effective cutting diameter, and so on; and fourthly, the actual coding and sequencing of the data.

Mr. Puckle discussed the relative merits of digital and analogue methods of control. The latter is the system preferred by E.M.I. principally

because it is more adaptable to minor changes in a complex programme and to compensating for the cutter diameter at the machine, and because it is "position conscious" rather than "increment conscious." In the written paper he describes in some detail the E.M.I. system.

E.M.I. now have an agreement with the Cincinnati Milling Machine Company and are currently developing numerical control for a large new Cincinnati gantry-type skin milling machine intended for milling complete integral wings. The cost of the numerical equipment is expected to be less than that of the template tables and associated equipment which it will replace. The machine has two vertical cutting spindles carried on saddles arranged for cross motion on a longitudinally-travelling gantry spanning the work. The control system has been so arranged that the two cutting heads work in parallel or in mirror image.

In the discussion which followed, it was apparent that not all the speakers were convinced of the time-saving advantages of numerical control in comparison with copying machines; it was, however, generally agreed that the numerically-controlled machine could be used with advantage for cutting the master templates accurately. One of the most interesting suggestions made was that, with the advent of numerical control, drawings could be dispensed with entirely, the designer defining the parts mathematically in the first place and coding them on punched cards which could be issued directly to the machine shops to form the basis for all production paperwork as well as for the actual control operations. The majority of the audience, however, probably agreed with the lecturer that the designer would be likely to have some difficulty in realising his concept without setting it down pictorially, even though only qualitatively, on paper.

The discussion on the three papers on hot-forming wrought magnesium alloys, the application of resistance welding, and contour etching, formed the single final session of the conference. The paper on "Contour Etching," by Mr. A. W. Shepphard of Saunders-Roe, Limited, is summarised in the previous article; Mr. Shepphard also showed a film of the etching pilot plant now in operation in the Saunders-Roe works.

HOT-FORMING WROUGHT MAGNESIUM ALLOYS

Wrought magnesium alloy sheets have for some years been widely used in the United States in airframe construction, for instance in the B.36 bomber, the B.47 and B.52 bombers and the Boeing 707 transport, and in an "all magnesium" version of the Lockheed F.80C trainer. In Great Britain, however, the proportion of wrought to cast magnesium alloys in aircraft construction amounts to less than 10 per cent. Mr. R. G. Wilkinson, development manager of Magnesium Elektron, Limited, presented a balanced case for the possibilities of wrought magnesium in a paper on "The Hot Forming, Assembly and Service Applications of Magnesium Alloys."

The principal advantage of using magnesium alloy sheet in place of aluminium alloy is that, for the same weight, a considerably stiffer structure can be obtained. In the all-magnesium F.80 aircraft, other advantages claimed are, through the use of a thicker skin, smoother aerodynamic contours, simplification of design and a reduced number of parts and fasteners, and a better fatigue resistance around rivet holes. New creep-resisting magnesium sheet and extrusion alloys are now becoming available which compare favourably with aluminium alloys.

Magnesium alloy sheet and extrusions, however, generally require hot-forming, at temperatures between 230 deg. and 250 deg. C. This brings certain advantages as compared with cold-forming other metals—for instance, deep draws are possible in a single operation, power requirements are reduced and, because springback is reduced as forming temperatures are increased, dimensional accuracy is more easily attained. Moreover, it is often possible to control dimensions by suitably adjusting the temperature of tools and stocks.

Magnesium alloy sheet derives much of its strength from "cold" working in the rolling operation; preheating before forming therefore acts as a "letting-down" anneal. In this respect, the British half-hard magnesium-zinc-zirconium alloy ZW3 compares favourably with the American hard-rolled magnesium-aluminium-zinc alloy FSIH24.

All the operations currently used for forming aluminium alloys can be successfully applied, working hot, to magnesium—press-braking, rubber-pressing, stretch-forming, spinning. In assembly, since magnesium is comparable to the highest-strength aluminium-base wrought alloys in notch-fatigue sensitivity, particular care is required to minimise stress raisers in mechanical and welded joints. For this reason, Mr. Wilkinson favours the use of argon arc welding in preference to riveting for jointing magnesium alloy assemblies. Special surface-protection treatments are now available for magnesium alloys used in rigorous aircraft applications where inaccessible components often have to operate in wells of accumulated condensate.

SPOT WELDING

Resistance welding is now being used increasingly in aircraft primary structures. Discussing "Recent Advances in the Application of Resistance Welding to Airframe Construction," Mr. N. K. Gardner, of Handley Page Limited, attributed the greater reliability now obtained in spot welds to the adoption of rigid process control. Resistance welding, he suggested, is likely to be increasingly favoured in high-speed aircraft where adhesives are impracticable and where metals such as titanium alloys, stainless steels and the nickel alloys—on the whole more readily weldable than present aluminium alloys—are likely to be used.

Typical examples of spot and seam welding include joining stiffeners to sheet—as in the Caravelle, Comet, Herald, Stratocruiser and Victor; fabricating fuel tanks, simplifying sealing problems, and de-icing ducts; joining floor beams and ribs; and, by Boeing, for pressure-cabin lap joints. The decision to use welding techniques must be made in the early stages of a projected design, and most effectively with collaboration between the designer and the production engineer. Among the factors to be taken into account are the strength and surface-finish requirements, the environment in which the joint will work, and whether sealing is required; from the manufacturing viewpoint, the accessibility of the component, the mobility of the equipment, size and thickness limitations, material limitations and economic considerations; and control and inspection methods.

In the production of the Victor prototypes and test components, 100 per cent. radiographic inspection was applied; of 300,000 welds, 2 to 3 per cent. were defective, mainly through lack of fit of mating parts; none fell below 50 per cent. of design strength. For the production machines, a graded sampling scheme of welds within assemblies was introduced. After a considerable period, the total number of welds was 7,230,000 of which 1,800,000 were inspected by radiography and 46,000 were found defective (2·5 per cent.) On this basis, radiographic inspection has been further reduced.

In the United States, many manufacturers have adopted spot welding in preference to riveting on the grounds of cost reduction. In the United Kingdom outputs are probably lower and costs are higher. Further advances in the use of welding techniques probably depend on the availability of professional production engineers capable of developing methods for overcoming outstanding problems.

In spite of Mr. Gardner's statistics, the discussion revealed some feeling that the use of spot welding in primary structure did not conform to the "fail-safe" concept. Mr. Gardner agreed that the Handley Page aircraft were not designed to "fail safe," but were designed to avoid failure. It was generally agreed that spot-welded skin panels should be designed to avoid buckling under compressive or shear loads.

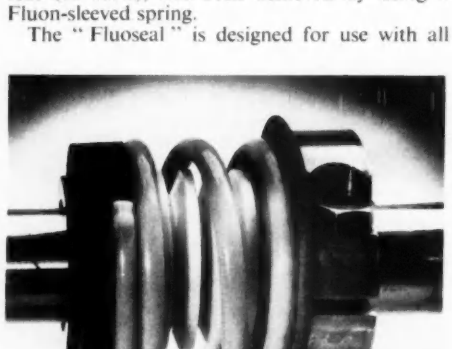
On the subject of contour etching, it was disclosed that Saunders-Roe are considering the application to steels, titanium and magnesium; but the problem is more complex. These materials require acid etching media, with consequent problems in tanks and fixtures, and in hydrogen embrittlement; the reactions are exothermic requiring the use of heat exchangers.

NON-CORROSIVE SEAL FOR SHAFTS

A mechanical seal for rotating shafts made entirely from Fluon, Fluon-loaded or Fluon-sleeved components has been produced by Crane Packing, Limited, Slough, Buckinghamshire. It is illustrated below.

The main seal member is a bellows of pure Fluon to which running faces of glass-reinforced Fluon have been welded. Spring loading, to maintain contact between the seal faces and the seat (or seats), has been achieved by using a Fluon-sleeved spring.

The "Fluoseal" is designed for use with all concentrations of acids and salts, strong oxidising agents or reducing agents, and it is also resistant to all organic compounds and salts. The only services for which the seal is not recommended without investigation are those handling strong alkalis such as caustic solutions of more than 50 per cent. concentration, or acid fluorides such as potassium bifluoride or hydrofluoric acid; the application of the seal is also restricted when a fluid contains solids in suspension.



A shaft seal made from Fluon is resistant to corrosion by acids and salts, and by alkalis of up to 50 per cent. concentration.

The normal pressure range is from 20 in. vacuum to 50 lb. per sq. in., and the normal temperature range between − 40 deg. C. and + 80 deg. C. The seal may be run dry indefinitely if arrangements are made for the dissipation of the heat generated at the seal faces the seal housing or pump casing, which can be accomplished with a clamp type ceramic seat.

The range of sizes in which the seal is at present supplied is for ¾ in. to 2 in. diameter shafts, and there are two versions of the design, one for external and the other for internal mounting.

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PLATINUM METALS REVIEW

With the object of providing engineers, chemists and metallurgists with a source of current information on the properties and industrial applications of platinum and its associated metals, a new quarterly journal, entitled *Platinum Metals Review*, has been introduced by Johnson, Matthey and Company, Limited, Hatton-garden, London, E.C.1. The first number contains several articles describing recent research work and industrial developments and also a series of abstracts of the relevant current literature.

HIGH SPEED DIESEL ENGINES

CURRENT TRENDS FOR FUTURE DESIGNS

In a paper entitled " Future Developments of the High Speed Diesel Engine " which was presented to the American Society of Mechanical Engineers at their annual meeting in November, Mr. E. Chatterton, the chief engineer of the Piston Engine Division of D. Napier and Son, Limited, gave his views as to the future developments of the high speed Diesel engine. The directions in which he thinks it will move are towards reduction in size and weight for increased power output. He went into the possibilities of increased power from a given size of cylinder, which can result from the combination of a Diesel engine and an exhaust-driven gas-turbine, operating with a high degree of super-charge. He discussed the limitations of this approach and drew conclusions as to the type of engine best suited for such developments. A brief report of the paper is given in this article.

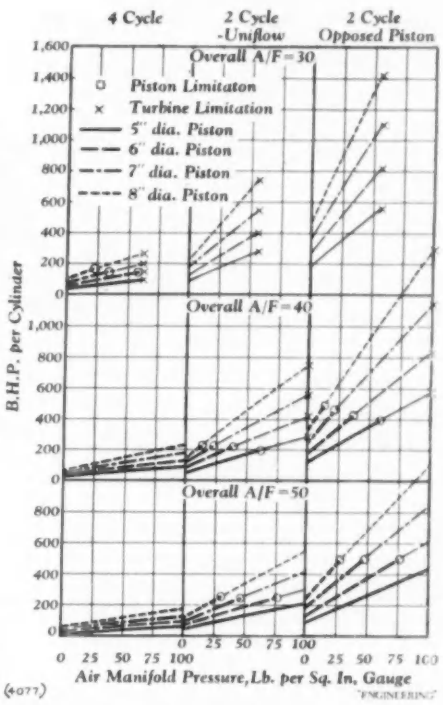
A " high speed Diesel engine " is one which is designed specifically for exploiting the decrease in weight that is possible by using a large number of small cylinders in an engine rotating at high speed. Such a design has useful applications wherever minimum size and weight are important, as for example, in marine work and rail traction. For example, four Napier Deltic engines, each delivering 1,700 h.p. at 1,500 r.p.m., driving through fluid couplings into a reverse/reduction gearbox would probably cost very much the same as a single direct drive reversing engine developing 6,000 s.h.p. at 110 r.p.m.; but the weight of the complete Deltic installation would be about 68 tons as compared to 460 tons for the slow speed engine. Furthermore, the engine room length would be reduced from 68 ft. to 28 ft. Again the saving in weight is demonstrated by the Napier Deltic locomotive, which develops 3,500 h.p. but has a specific weight of only 71 lb. per h.p.

The basic problem is how to produce the maximum b.h.p. per cubic inch of cylinder volume. Fuel can be injected at any desired rate, but it is the question of air supply which is the major problem in the development of high speed engines. Increase of speed beyond about 2,200 r.p.m. causes difficulties with the valve gear, and with the fuel injection gear. The mean piston speed also increases and it is generally accepted that this should not exceed 2,000 ft. per minute, although some engines do run as fast as 2,500 ft. per minute. An engine designed to operate under these conditions would have a stroke of about 5·8 in. which gives an indication of the size of cylinder involved.

For the three different types, the four-stroke cycle, the two-stroke uniflow cycle and the two-stroke opposed piston, a heat balance sheet is worked out assuming that the super-charge pressure is balanced against the effective compression ratio so as to maintain a compression pressure of 690 lb. per sq. in., which will ensure that the practical limitations of maximum cylinder pressure will not be exceeded. Allowing for the total heat absorbed in driving the super-charger, and assuming that the turbine inlet temperature does not exceed 2,000 deg. F. it is possible to obtain curves showing the performance of the three types of engine. Assuming also that the turbine inlet pressure is taken to be 86 per cent. of the super-charging pressure, and that the piston temperature does not exceed 800 deg. F. as obtained by calculation, the diagram on the right can be obtained for the three types. This diagram shows clearly that for any size of cylinder, the opposed-piston type is capable of producing higher specific outputs than either of the others with the same limitation.

A very considerable influence is exerted on the power output by the efficiency of the super-charger, particularly when high degrees of super-charge are used, and therefore for high manifold pressures, an axial-flow super-charger may be regarded as essential. From the heat balance diagrams it can be shown that the turbine is capable of producing more power than is absorbed by the super-charger. To take full advantage of this excess power, the turbine must therefore be geared back into the engine output, thus forming a " compound " engine. It can also be shown that in the case of a 5 in. diameter piston, the b.h.p. per cub. in. can be increased by super-charging to three times its value at zero manifold pressure with no increase in piston temperature.

It would therefore seem that the greatest possibility for reduction of engine size and weight is offered by a highly super-charged two-stroke engine, compounded with a turbine driving an axial-flow compressor. The cylinder layout which offers the greatest potentiality for such development is the opposed-piston design. One solution of the mechanical layout for the whole engine is that of three cylinders, each having opposed pistons, arranged in the form of a triangle, as they are developed in the Deltic. The space between the cylinders provides room for an axial-flow super-charger, giving a compact compound engine which weighs about 2½ lb. per b.h.p. for an output of 5,500 b.h.p.



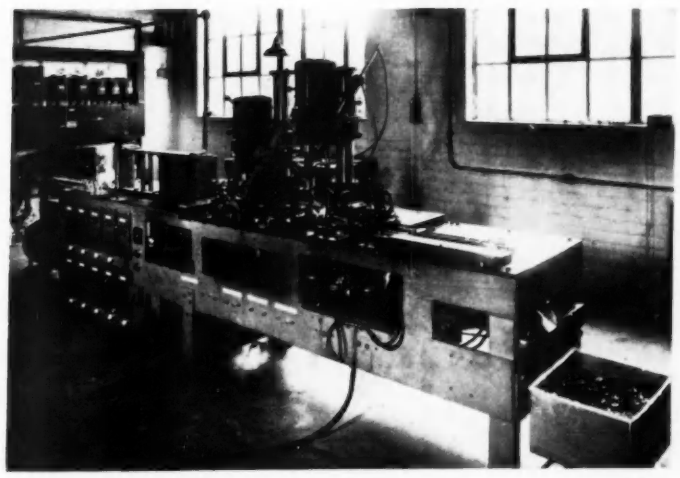
Conditions assumed: engine speed 2,200 r.p.m; maximum turbine inlet temperature 2,000 deg. F.; compression pressure 690 lb. per sq. in.; maximum piston temperature 800 deg. F., mean piston speed 2,000 ft. per min.

Curves obtained by calculation show that the two-stroke opposed-piston engine can develop more power per cylinder than other types.

MAKING NUTS FROM LAMINATED PLASTICS

In making nuts from laminated material, it has not been possible, until recently, to use a normal automatic bar machine, since tapping must be carried out perpendicular to the plane of lamination.

To solve this problem, Permali Limited, Bristol-road, Gloucester, have now developed a machine which automatically forms nuts from strip stock, principally Permali densified-wood phenolic laminates. The machine, shown in the accompanying illustration, has an output of six completed nuts per minute, in Whitworth and other standard threads, in sizes from ⅜ in. to ¾ in., and the speed of production is governed at present by the tapping process. The sequence of operations starts with strips of Permali being loaded into the magazine—the latter holding sufficient material for one hour's continuous operation. Re-loading can, however, take place while the machine is working. Each strip is then automatically ejected from the magazine, fed forward, and first drilled and chamfered with a single tool. (Provision is made for chamfering on the opposite side for lock nuts only.) This is followed by tapping and, finally, the hexagon is formed by sawing. Until sawing takes place, all operations are simultaneous on several nuts, in strip form, and there are five operations in each cycle. Safety devices are incorporated throughout, including an automatic stop.



The machine illustrated automatically forms nuts, at a rate of six per minute, from laminated strip material, such as densified-wood phenolic laminates. It drills and chamfers, taps and finally saws the hexagon.

Previously, the making of such nuts, used in very large numbers on transformers and other oil-immersed apparatus subject to a fairly wide temperature variation, involved the use of three separate machines and operators, so that, as will be appreciated the installation of the machine has allowed re-deployment of labour on more intricate machine work.

The drilling, tapping and feeding movements are hydraulically operated and controlled by master cams made to the drawings of Permali Limited. The remainder of the feed mechanism is pneumatically operated and electrically controlled with standard equipment supplied by Benton and Stone Company, Limited, Birmingham, with micro-switches from Burgess Products Limited, Gateshead, the whole being modified to suit the particular requirements involved.

The clamping arrangements were designed by Permali Limited, and operated by Martonair valves and cylinders. The air compressor, supplied by William and James, Limited, Gloucester, is an integral part of the machine and a standard unit with a special variable pressure controller for setting within a very wide range.

ATOMIC REVIEW

Essential Services

Under-developed countries as potential markets—India builds atomic energy establishment—Nuclear co-operation between African and Asian countries—India's swimming-pool reactor—Canada builds high-flux reactor at Trombay—India to make fuel elements and moderator graphite—Thorium plant expanded—Heavy water as fertiliser by-product—Nuclear centre to be built in Philippines for Colombo Plan countries—Electrical output from boiling-water reactor—Metal hydrides as moderators—Nautilus refuelled—Fifth group announce civil contractors—Nuclear Power Plant Company activities—Britain is leading isotope exporter—Thickness gauges identified—O.E.E.C. conference on nuclear energy for management—Services to man—Unwanted stations.

Potential Markets

One of the significant features of our times is the industrial development of countries once thought to be backward. Atomic energy being foot-loose—not chained to local resources, geographical features or transport systems—is likely to be of great service to such countries, but for some time at least they will still depend on the technology of the West. For the West, therefore, they represent the opportunity for trade. Successful trading, however, depends on a knowledge of the market and the current stage of progress in the country concerned. As a background to atomic energy development in India, we publish below an account of work completed or in progress there during the past year. The article is based on information taken from a report by Dr. Homi J. Bhabha printed in *United Nations Review*, and from *Far East Trade* and various other sources. A previous article dealing with developments in an overseas country, in this case Japan, was published in ENGINEERING on January 4, page 28.

INDIA

Foundations for the Future

The question has been put: how quickly can Asia enter the age of atomic power? Both Japan and China have formulated experimental programmes, but the obvious advantages of short-circuiting, so far as possible, other sources of power have been outweighed by the difficulty of introducing nuclear power into under-developed—or at least, only partially industrialised—economies. But India has taken the step. Speaking last May on India's second five-year plan, Mr. Pandit Nehru laid particular emphasis on the importance of accelerating the use of atomic energy.

The leading figure in India's atomic energy development is Dr. Bhabha, chairman of the Indian Atomic Energy Commission, who first won an international reputation by papers on quantum theory and cosmic radiation, and who in 1955 was appointed president of the International Conference on the Peaceful Uses of Atomic Energy in Geneva. Obtaining his bachelor's degree and doctorate at Cambridge, he later became professor of theoretical physics at the Tata Institute of Fundamental Research, and subsequently chairman of India's A.E.C. His principal work while chairman of the commission has been the planning and building of the Indian Atomic Energy Establishment on Trombay island, some 12 miles from Bombay. Dr. Bhabha said last August that he hoped India would have her first atomic power station within five years.

Asian-African Co-operation

Dr. Bhabha was also chairman of a conference for scientists from India, Burma, Ceylon, Indonesia and Egypt held in Bombay last July. The purpose of the meeting was to discuss systems for closer co-operation in atomic energy development, and for linking the programmes of the five countries to avoid duplication. It was reported that good progress in the establishment of a common policy was made; and that subsequent meetings would be held, possibly to include representatives from other Asian and African countries.

Swimming-Pool Reactor

During the year, India's first reactor (also the first in Asia outside the Soviet Union) was completed at the Trombay establishment. Of swimming-pool design and costing Rs. 27½ million (£2 million), it became critical on August 4, 1956, and has since been undergoing trial runs. Loading commenced on July 30 but certain difficulties were experienced before criticality was achieved later in the week; it was reported that some damage had occurred to fuel elements during transit to India, causing distortion, and a violent monsoon was in progress at the time of loading. The reactor, which is rated at 1 MW, is illustrated in Fig. 1. The design of the experimental facilities and engineering for the reactor was carried out by Indian scientists and engineers, and the construction work took about a year to complete; only 16 months before criticality it was in the drawing board stage. It will be used for training purposes, experimental physics and the preparation of radioactive isotopes, and will be made available to scientists of other countries in the area and beyond, to the limited extent that space and facilities permit.

The core of the reactor is of standard design, and the enriched fuel elements were supplied by the United Kingdom Atomic Energy Authority under a bilateral agreement signed soon after the Geneva Conference. The core moves horizontally (as in the case of LIDO) in a pool 28 ft. long by 10 ft. wide contained in a vessel of 8½ ft. thick concrete, which stands in a hall 100 ft. by 50 ft. by 70 ft. high. The core is a 2 ft. cube comprising 25 to 30 DIDO or MTR type fuel elements. In addition to experimental channels, a graphite thermal column 6 ft. square is provided at one end of the pool; at the other are facilities for shielding experiments. There are, of course, numerous safety devices to operate in the event of instrument failure or excessive heat generation.

Heavy-Water Reactor

Early in 1955 the Prime Minister of Canada offered a high-flux natural-uranium heavy-water

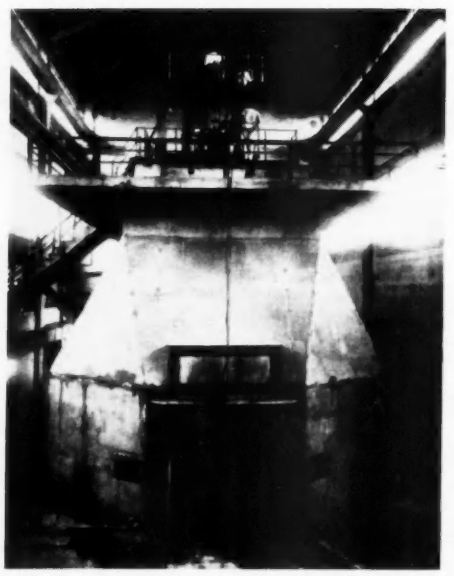


Fig. 1 The Indian atomic energy establishment on Trombay Island, near Bombay, includes a swimming-pool reactor, which became critical last year.

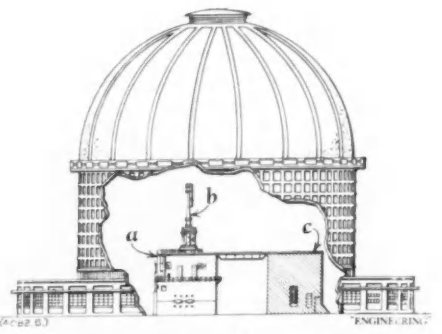


Fig. 2 By an agreement between Canada and India under the Colombo plan, a second reactor similar to the Canadian NRX is being built at Trombay. The sketch shows the reactor (a), the fuel-element removal flask (b), and a storage block (c), all within a dome 120 ft. in diameter.

reactor of the NRX type (NRX is discussed in ENGINEERING, vol. 180, page 299, 1955) to the Government of India. The new reactor, which is to be supplied by Atomic Energy of Canada Limited under the Colombo Plan, will be known as CIR (Canada-India Reactor) and a sketch showing the general layout of the installation appears in Fig. 2. CIR will be used for advanced engineering research and materials testing, and is due to come into operation in the first half of 1958, but there have been reports that it may be ready by the end of the present year. The reactor is being built by the Foundation Company of Canada Limited with a consortium of Commonwealth firms, including the Shawinigan Engineering Company, Limited, of Montreal, and the project is being financed jointly by Canada and India; Canada will contribute just over half—7·5 million dols. of the 14 million dols. total. The NRX reactor at Chalk River, Ontario, which is shown diagrammatically in Fig. 3, is rated at 40 MW (heat) with a maximum thermal neutron flux of $6{\cdot}8 \times 10^{13}$ neutrons per sq. cm. per second, though a figure of 30 MW has been published for the Indian project.

During the Geneva Conference members of the two delegations discussed details of the proposed reactor for India and the modifications which would have to be made in order to allow for the difference in the environmental conditions of Trombay and Chalk River. As Dr. Bhabha stated in his report last November to the United Nations:

> "In Trombay we have no river with such a plentiful supply of cold water as at Chalk River, and if such a reactor were set up in India, the cooling system would have to be different. We came to the conclusion during the Geneva talks that the problem could be solved, and the decision to accept the generous offer of the Canadian Government was taken. I visited Chalk River early in October with a group of Indian scientists, and we had discussions with our Canadian colleagues about the detailed design of the reactor and about the many arrangements which had to be made to advance the project. Immediately on my return to India in October, we tentatively selected a location for the reactor on the site of our Atomic Energy Establishment at Trombay, and began test borings to study the ground and the rock formation below. Some of our Canadian colleagues visited Trombay in January this year, and we fixed on the exact location. The contract for the excavation, foundation and building work for the reactor was given on our side in February this year. The formal agreement between the Governments of Canada and India was signed in New Delhi on April 28, 1956, by the Prime Minister of India and the Canadian High Commissioner. Under this agreement Canada makes available the reactor proper, while India will be responsible for its erection and provision of the associated laboratory and engineering facilities."

As shown in Fig. 2, the reactor will be housed in a hermetically sealed steel shell, so that in the event of an accident radioactive products will not escape to atmosphere. The moderator will be heavy water which has been sold to India by the United States; the first 7 tons of the 21 ton

shipment arrived in Bombay last June. Canada is responsible for the design work, the reactor itself, engineering and erection, and the steel for the dome, which is 135 ft. high and 120 ft. in diameter. Indian personnel are being trained in operation on NRX at Chalk River. In Fig. 2, (*a*) is the reactor; (*b*) the fuel rod removal flask; and (*c*) the storage block. Spent elements will be drawn from the core and up into a 25 ton lead-lined flask. The flask then moves across the bridge over to the concrete storage block, into which the irradiated elements are lowered, and on to a carriage that travels in a water-filled trench to a chemical processing plant. A revolving crane similar to that above DIDO will be supported on rails at the base of the cupola. It has been reported that there are to be several improvements on the NRX design: these will include more extensive facilities for experiments on power reactor development, a greater number of holes through the shielding for physics experiments, and advanced control and instrumentation.

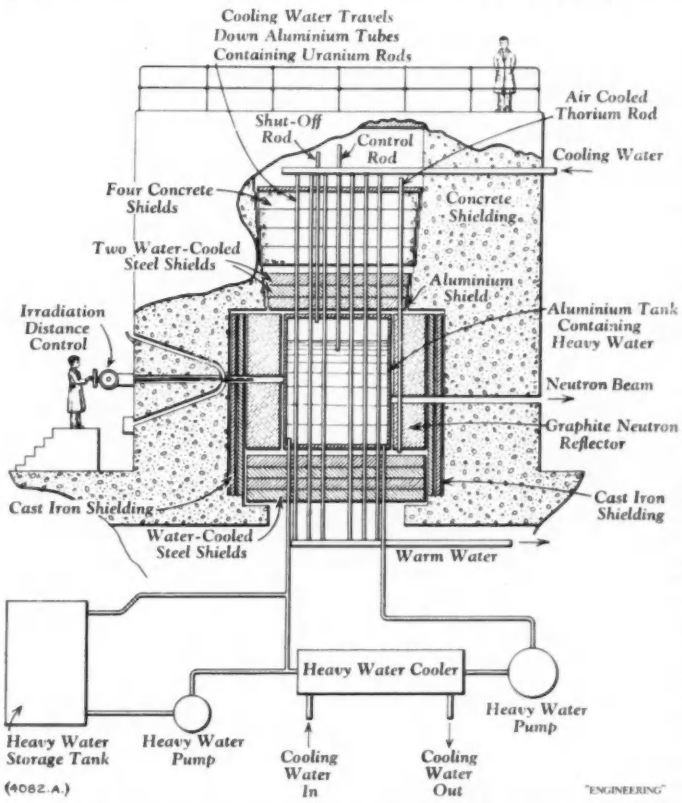


Fig. 3 The second Trombay reactor is based on the high-flux heavy-water moderated reactor NRX, at Chalk River, shown here diagrammatically.

Fuel Elements and Graphite

Dr. Bhabha has stated that India has undertaken to build a plant for producing natural-uranium fuel elements for the country's future reactors. India also intended to make her own high-purity graphite for reactor moderators.

Thorium

Since the Geneva Conference, the capacity of India's thorium extraction plant at Trombay has been expanded several fold. The plant was built to exploit the large monazite sand deposits, yielding both uranium and thorium, located in Travancore-Cochin. Two months after the completion in August, 1955, of an original enlargement, a 30 per cent. increase in production was found possible. It is considered that India will not only be able to supply her own needs, but also make considerable quantities available for export. Until 1946 the bulk of the world's thorium ore had come from India, but since then export restrictions have limited foreign purchase of this mineral.

Heavy Water

Studies have been completed and construction begun on a large fertiliser plant at Nangal in the Punjab, where substantial quantities of heavy water will be made as a by-product. Production of heavy water is likely to begin in 1960. The possibility of making heavy water at the large Government-owned fertiliser plant at Sindri has also been investigated, but it is not known whether a decision has been made. It is because India requires large quantities of ammonium sulphate or nitrate for use as fertiliser, that the production of heavy water in this way is economical. According to an American chemical engineer, Mr. G. T. Austin, working at the Indian Institute of Science, heavy-water manufacture may also one day be economically carried out in India from bitterns, a waste product of salt production. These techniques presumably depend on the concentration of heavy or light water as water of crystallisation in crystals of the various chemicals, which evidently show a preference for water of one kind. The process would probably involve cascade cycling.

GENERAL NEWS

Asian Nuclear Centre

Details have been given of the proposed Asian regional nuclear centre to be built in the Philippines in association with the Colombo Plan countries. United States plans are based to a great extent on the findings of a mission that has been conferring with Asian scientists over the past three months. The centre would contain laboratories and equipment for research in the basic sciences; general nuclear facilities such as a research reactor, radiation sources and an isotope laboratory; and extensive special facilities for application studies in medicine, agriculture and industry, including a clinical research hospital. Ultimately a demonstration power reactor might be added. The centre would accommodate about 200 students in the initial phase, rising to 1,000. Leading American scientists will assist in running the centre until the countries concerned have sufficient experience to run it themselves. The United States has pledged 20 million dols. to help establish and operate the centre.

Power from Boiling-Water Reactor

The Argonne National Laboratory, of Lemont, Illinois, U.S.A., has recently announced that an experimental boiling-water reactor (EBWR), with a heat rating of 20 MW, had achieved a peak electrical output of 5 MW. The Laboratory is operated by the United States Atomic Energy Commission and the electricity was produced by one of five boiling-water reactors established there.

Solid Hydride Moderators

Solid metal hydrides are proposed as reactor moderators in an article in *Nucleonics* (November, 1956) by Mr. H. M. McCullough and Mr. B. Kopelman, of Sylvania Electric Products, Atomic Energy Division, Bayside, New York. Since hydrogen, the ideal moderator, is gaseous at ordinary temperatures, it is desirable to increase its concentration by combining it with another element to form a liquid or solid compound. Light (H_2O) or heavy (D_2O) water are examples, but their lack of thermal stability sometimes makes their use inconvenient in high-power reactors. The negligible neutron-absorbing properties of elements such as cerium, zirconium and calcium give their hydrides considerable possibilities as moderators. Other qualities required are thermal and chemical stability at temperatures up to 1,250 deg. C. (2,400 deg. F.), sufficient strength to support their own weight at least without distortion, and relatively low vapour pressure at the operating temperature. The hydrides of the fissile or fertile elements, thorium, uranium and plutonium tend to be brittle.

Marine Propulsion

Nautilus, the United States 3,000 ton 300 ft. atomic powered submarine, reported some time ago to have travelled over 50,000 miles under her own power, is believed to have been refuelled. It is said that the vessel's range on a single charge is considerably greater than that covered, but that after such a distance power output diminishes rapidly.

Civil Contractors for Fifth Group

We referred recently to the formation of a fifth United Kingdom nuclear power group (Atomic Power Constructions Limited) by Richardsons Westgarth and Company, Limited, International Combustion (Holdings) Limited and Crompton Parkinson Limited. It has now been announced that the building, civil engineering and structural work will be undertaken by Trollope and Colls Limited in association with Holland and Hannen and Cubitts Limited. These civil contractors have been engaged on thermal and hydro-electric power stations, and Trollope and Colls Limited have had considerable experience in atomic work, having been engaged as the main contractors for seven years on the plutonium plant at Windscale, and the diffusion plant at Capenhurst.

Plant for Nuclear Power

The latest issue (vol. 7, No. 43) of the *Heaton Works Journal*, the house magazine of C. A. Parsons and Company, Limited, is a nuclear power plant number devoted to the contributions which the member firms of the Nuclear Power Plant Company, Limited, will make to the construction of future atomic power stations. There are articles dealing with steam and generating plant, control gear, reactor equipment, reactor pressure vessels, fuel handling equipment, structural steel and other items concerned with atomic power stations. Reference is also made to past activities by the various companies in the atomic energy field, including contracts for Calder Works, DIDO and the Windscale and Capenhurst plants. The Nuclear Power Plant Company have secured the contract for the atomic power station at Bradwell.

Isotope Exports

United Kingdom radioisotope production reached the record figure of 22,069 during the 12 months, October, 1955, to September, 1956, exceeding the corresponding previous figure by 3,830 consignments; 37 per cent. of the total number of consignments were exported. During the 12 month period 47 countries imported 8,617 consignments worth £100,000. Germany received the greatest number of consignments (1,266) but the United States led in terms of monetary value with only 170. Rumania, among the Soviet satellites purchased 90 consignments. In Britain the usage of radioisotopes was mainly in hospitals, but they are increasingly being applied to on-site radiography and research; 13,425 consignments were used in the United Kingdom. Other figures are: France 1,051; Sweden, 1,022; and Japan, 698 consignments.

The preparation of radioactive isotopes, mainly from reactor wastes, but also by the special irradiation of samples, is carried out at Harwell and the Radiochemical Centre, Amersham. Britain leads the world in radioisotope exports, and production and sale are rising.

Thickness Gauges

The name "Atomat," which has now been registered as a trade mark for nucleonic thickness

gauges made by the Baldwin Instrument Co. Ltd., Dartford, Kent, will apply to beta, gamma, Bremsstrahlung and X-ray gauges as well as to the company's transverse profiler. The Atomat makes use of radioactive isotopes to measure, without contact, thickness or weight per unit area of any sheet materials such as paper, board, metals, plastics, rubber, linoleum or leathercloth. Baldwin gauges of this kind have previously been described in ENGINEERING (vol. 179, page 190, 1955).

Nuclear Energy for Management

A Conference on nuclear energy for management has been organised by the O.E.E.C. European Productivity Agency, assisted by the Organisation's Nuclear Energy Secretariat, to take place in Paris from April 1 to 6 this year. The purpose of the conference is to provide industrialists with information on: the present state of nuclear technical development and the progress made in this field; the economic prospects offered to the European countries and their overseas territories by the development of this new form of energy; the new problems involved in the construction and operation of nuclear plant, especially for the metallurgical, chemical and mechanical engineering industries; and the opportunities offered by the use of radioisotopes in industry.

The principal papers presented will deal with the different types of reactors, the first nuclear power plants (Calder Hall in the United Kingdom, Marcoule in France and Shippingport in the United States), the various elements of nuclear energy costs, special materials and equipment required by the nuclear industry, the present position of national programmes and the action being taken at international level. The chairman at the first day's meeting will be Professor Francis Perrin, High Commissioner for Atomic Energy (France).

Faraday Lecture

"Nuclear Energy in the Service of Man" is to be the subject of the 1956/57 Faraday Lecture, which will be delivered by Dr. T. E. Allibone. The lecture will be of an introductory nature dealing with the different ways in which atomic energy can be put to practical use and the history of its application. Dr. Allibone, who has been concerned with controlled fusion experiments at the A.E.I. research laboratories at Aldermaston, will refer to this process, mentioning the generation of high temperatures by "pinch effect." The lecture, which will be very comprehensive in its scope, will first be delivered at the Central Hall, Westminster, London, S.W.1, on February 13 (6 p.m.).

Admission is by ticket obtainable from the Institution of Electrical Engineers. Other towns in which the lecture will be delivered and the corresponding dates will be given in Notices of Meetings in due course.

Postscript

Referring to the atomic energy research station which the U.K.A.E.A. are proposing to build on Winfrith Heath, in Dorset, the *Western Mail* states: "There is wide support in Dorset for siting the station in Wales." The Welsh Economic Development Council are not opposed to this view and consider it "essential that Wales should have a full share in the development of atomic energy." Not only are the Council bidding for the research establishment, but Lord Citrine has announced that the Central Electricity Authority is investigating the possibility of siting a nuclear power station in Wales. Unfortunately the Council's farsightedness is not equalled elsewhere in Cambria, for Llandudno Council has refused to support Llanfairfechan's claims to be chosen as the site of the Gwynedd power station. Hampshire, too, has been quick to cold shoulder the Atomic Energy Authority, but the proposed Dorset establishment is now likely to go ahead. It is a situation that would no doubt have appealed to Hardy, whose name has been so much invoked by the dissidents of Dorset.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

NOTTINGHAM
"The Nature of Plastics," with film, by H. H. Lusty. Nottingham Branch. Offices of the East Midlands Electricity Board, Smithy-row, Nottingham. Wed., Jan. 23, 7.30 p.m.

Building Centre

LONDON
Films on "Gypsum in Building" exhibited by British Plaster Board (Manufacturing) Ltd. Wed., Jan. 23, 12.45 p.m.

Chemical Society

LEEDS
"Fibre Science and Leather Production," by Dr. H. Phillips. Leeds Branch. Chemistry Lecture Theatre, The University, Leeds. Mon., Jan. 21, 7 p.m.
NEWCASTLE-UPON-TYNE
"Polymerisation in Heterogeneous Systems," by Professor C. E. H. Bawn. Newcastle and Durham Branch. Chemistry Building, King's College, Newcastle-upon-Tyne. Fri., Jan. 25, 5.30 p.m.
ST. ANDREWS
"Colour Photography," by R. B. Collins. St. Andrews and Dundee Branch. St. Salvator's College, St. Andrews. Fri., Jan. 25, 5.15 p.m.

Combustion Engineering Association

LONDON
"The First Ten Years of the National Coal Board," by Noel Gee, at 10.30 a.m., and "The Effect of Coal Characteristics on the Operation of Mechanical Stokers," by D. C. Gunn, at 2.30 p.m. London Section. Kingsley Hotel, Bloomsbury-way, W.C.1. Wed., Jan. 23.

Illuminating Engineering Society

BIRMINGHAM
"Lighting of Educational Institutes," by A. G. Sheppard Fiddler. Birmingham Centre. Regent House, St. Phillip's-place, Colmore-row, Birmingham. Fri., Jan. 25, 6 p.m.

Incorporated Plant Engineers

CARDIFF
"The Factories Acts," by R. H. Thompson. South Wales Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Jan. 22, 7.15 p.m.
LIVERPOOL
"Method Study," by G. St. G. Wheeley. Mersey and North Wales Branch. Exchange Hotel, Liverpool. Thurs., Jan. 24, 7.15 p.m.

Institute of British Foundrymen

CARDIFF
Film Evening. Wales and Monmouthshire Branch. South Wales Institute of Engineers, Park-place, Cardiff. Fri., Jan. 25, 6 p.m.
NEWPORT
"Mechanism of the Solidification of Cast Iron," by H. Morrogh. Wales and Monmouthshire Branch. Whitehead Institute, Newport. Tues., Jan. 22, 7 p.m.

Institute of Fuel

LONDON
"Chemistry of Coal and Its Relation to Coal Carbonisation," by Dr. I. G. C. Dryden. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Jan. 23, 5.30 p.m.*

Institute of Marine Engineers and Institution of Naval Architects

SOUTHAMPTON
"Air Conditioning of Ships," by J. K. W. MacVicar. Southern Joint Branch. Southampton Technical College, St. Mary-street, Southampton. Thurs., Jan. 24, 7.30 p.m.

Institute of Marine Engineers

BATH
"Some Considerations of Wear in Marine Gearing," by Dr. W. H. Darlington. West of England Section. York House Hotel, George-street, Bath. Mon., Jan. 21, 7.30 p.m.
CARDIFF
Annual General Meeting. South Wales Section. South Wales Institute of Engineers, Park-place, Cardiff. Mon., Jan 21, 6 p.m.

Institute of Metals

SHEFFIELD
"Research Work in the Department of Metallurgy of the University of Sheffield," by Professor A. G. Quarrell. Sheffield Local Section. The University, St. George's-square, Sheffield. Mon., Jan. 21, 7.30 p.m.

Institute of Road Transport Engineers

DURHAM
"High Pressure and Syndromic Lubrication Systems," by W. T. Kay. North Eastern Centre. Three Tuns Hotel, Durham City. Tues., Jan. 22, 7 p.m.

Institution of Chemical Engineers

MANCHESTER
Annual General Meeting. North Western Branch. Grand Hotel, Manchester. Fri., Jan. 25, 3.30 p.m.

Institution of Civil Engineers

LEEDS
"Organisation and Control of Highways Maintenance," by W. J. Hiscock. Yorkshire Association. Hotel Metropole, Leeds. Fri., Jan. 25, 6.15 p.m.

Institution of Electrical Engineers

LONDON
"Television Film Recording," by E. J. Stocks. London Graduate and Student Section. Mon., Jan. 21, 6.30 p.m.*
"Design Considerations for Junction-Transistor Oscillators for the Conversion of Power from D.C. to A.C.," by F. Oakes; "Junction-Transistor Bootstrap Linear Sweep Circuits," by K. P. P. Nambier and Dr. A. R. Boothroyd; and "Minority-Carrier Storage in Semi-Conductor Diodes," by J. C. Henderson and Dr. J. R. Tillman. Radio and Telecommunication Section. Wed., Jan. 23, 5.30 p.m.*
Symposium of papers on "The Transatlantic Telephone Cable." Joint meeting, linked by the cable, with the American Institute of Electrical Engineers and the Engineering Institute of Canada. Thurs., Jan. 24, 6.45 p.m.*
LIVERPOOL
"Electronic Control of Machine Tools," by N. Milne. East Midland Centre. 9 The Temple, 24 Dale-street, Liverpool. Wed., Jan. 23, 6 p.m.
"The Pressurised Water Reactor as a Source of Heat for Steam Power Plants," by Dr. J. M. Kay and F. J. Hutchinson. East Midland Centre. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Thurs., Jan. 24, 6 p.m.
WEYMOUTH
"Germanium and Silicon Power Rectifiers," by T. H. Kinman, G. A. Carrick, R. G. Hibberd and A. J. Blundell. Southern Centre. South Dorset Technical College, Weymouth. Fri., Jan. 25, 6.30 p.m.

Institution of Engineering Designers

LONDON
"The Demands of Standards on Engineering Design," by E. W. Greensmith. Tues., Jan. 24, 6.45 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"The Education and Training of Technologists," by Sir David S. Anderson; and "The Education and Training of Technicians and Craftsmen in the Shipbuilding and Engineering Industries," by Dr. W. S. Cormack. Tues., Jan. 29, 6.30 p.m.*

Institution of Heating and Ventilating Engineers

BRISTOL
"Process Steam," by L. G. Northcroft. South Western Branch. Library, R.W.A. School of Architecture, Bristol. Tues., Jan. 22, 6.30 p.m.
LIVERPOOL
"School Heating Systems," by C. A. Reynard. Liverpool Branch. College of Building, Clarence-street, Liverpool. Wed., Jan. 23, 6.30 p.m.

Institution of Highway Engineers

LONDON
"Snow," by E. W. H. Vallis. Institution of Structural Engineers, 11 Upper Belgrave-street, S.W.1. Fri., Jan. 25, 5.30 p.m.

Institution of Locomotive Engineers

LONDON
"Diesel Locomotive Building and Maintenance," by T. F. B. Simpson. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., Jan. 23, 5.30 p.m.*
BIRMINGHAM
"Hydraulic Buffers," by D. L. Turner. Midlands Centre Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Tues., Jan. 22, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke-street, St. James's, London, S.W.1. (WHItehall 5536.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Highway Engineers, 47 Victoria-street, London S.W.1. (ABBey 3891.
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
King's College (University of London), Strand, London, W.C.2. (TEMple Bar 5454.)
Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool 2. (Central 3717.)
Manchester Association of Engineers, 18 Booth-street, Manchaster 2. (Central 1717.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne 1. (Newcastle 20289.)
Prestressed Concrete Development Group, Terminal House, Grosvenor-gardens, London, S.W.1. (BELgravia 6661.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Society of Health, 90 Buckingham Palace-road, London, S.W.1. (SLOane 5134.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)
Society of Chemical Industry, 14 Belgrave-square, London, S.W.1. (BELgravia 3681.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.

Institution of Mechanical Engineers

LONDON
Discussion on "Diagnosis of Mechanical Troubles." Applied Mechanics Group. Thurs., Jan. 24, 6.45 p.m.*
"An Investigation into the Mechanism of Oil Loss Past Pistons," by Dr. P. de K. Dykes; and "A Study of Piston Ring Lubrication," by Professor O. A. Saunders and Dr. S. Eilon. Meeting in conjunction with the Automobile Division, and the Internal Combustion Engine and Lubrication Groups. Fri., Jan. 25, 6 p.m.*
"Some Highlights in the History of Mechanical Engineering," by E. G. Sterland. Annual Students' Lecture. London Graduates' Section. Sat., Jan. 26, 3 p.m.

BRISTOL
Graham Clark Lecture on "The Impact of Engineering on Society," by Sir Maurice Bowra. Western Branch. Engineering Laboratories, The University, Bristol. Tues., Jan. 22, 7 p.m.

DUNDEE
Repetition of Presidential Address on "Motive Power on Sea and Land," by T. A. Crowe. Scottish Branch. Technical College, Dundee. Wed., Jan. 23, 7.30 p.m.

FARNBOROUGH
Annual General Meeting and Chairman's Address. Southern Branch. Royal Aircraft Establishment Technical College, Farnborough. Wed., Jan. 23, 7.30 p.m.

GLASGOW
Repetition of Presidential Address on "Motive Power on Sea and Land," by T. A. Crowe. Scottish Branch. Royal College of Science and Technology, George-street, Glasgow. Tues., Jan. 22, 7.30 p.m.

LIVERPOOL
"The Pressurised Water Reactor as a Source of Heat for Steam Power Plants," by Dr. J. M. Kay and F. J. Hutchinson. North Western Branch. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Thurs., Jan. 24, 6 p.m.

Institution of Production Engineers

BELFAST
"Blending of High Quality with Low Cost in Engineering Production," by J. Loxham. Northern Ireland Section. Kensington Hotel, College-square East, Belfast. Thurs., Jan. 24, 7.30 p.m.

CARDIFF
"Human Relations in Industry," by D. W. Collier. South Wales Section. South Wales Institute of Engineers, Park-place, Cardiff. Fri., Jan. 25, 7 p.m.

MIDDLESBROUGH
"Precision Casting," by J. S. Turnbull. Tees-Side Section. Cleveland Scientific and Technical Institution, Corporation-road, Middlesbrough. Tues., Jan. 22, 7 p.m.

NEWCASTLE-UPON-TYNE
"Production of Turbine Blading," by R. Pickard. North Eastern Section. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Jan. 21, 7 p.m.

Institution of the Rubber Industry

LIVERPOOL
"Recent Technical Developments," by W. P. Fletcher, Merseyside Section. 24 Hatton-garden, Liverpool. Mon., Jan. 21, 7.15 p.m.

Institution of Structural Engineers

LONDON
"Water Towers," by J. O. C. Ritchie. Thurs., Jan. 24, 6 p.m.

BIRMINGHAM
"Calculation of Bending and Torsional Effects in Girders," by J. S. Terrington. Midland Counties Branch. James Watt Memorial Institute, Great Charles-street, Birmingham. Fri., Jan. 25, 6 p.m.

MANCHESTER
"Instability Effects in the Plastics Range," by Dr. W. Merchant. Lancashire and Cheshire Branch. College of Technology, Manchester. Tues., Jan. 22, 6.30 p.m.

Junior Institution of Engineers

LONDON
"Mechanical Aim and Progress in Fire-Fighting Equipment," by Edmund S. Calvert. Fri., Jan. 25, 7 p.m.*

King's College, London

LONDON
"Undergraduate and Post-Graduate Education of Engineers in European Countries," by Professor S. J. Davies. Public Lecture. Mon., Feb. 4, 5.30 p.m.

Liverpool Engineering Society

LIVERPOOL
"Electronic Control of Machine Tools," by N. Milne. Wed., Jan. 23, 6 p.m.

Manchester Association of Engineers

MANCHESTER
Discussion on "Smokeless Zones." Engineers' Club, Albert-square, Manchester. Fri., Jan. 25, 6.45 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
"A Method of Analysing Voyage Data," by R. E. Clements. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Fri., Jan. 25, 6.15 p.m.

Prestressed Concrete Development Group

LONDON
Annual General Meeting. "Progress of Prestressed Concrete in the Netherlands," by Ir. A. S. G. Bruggeling. Institution of Civil Engineers, Great George-street, S.W.1. Thurs., Jan. 24, 6 p.m.*

Royal Aeronautical Society

LONDON
"Aeronautical Research in Holland," by Professor H. J. van der Maas. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Thurs., Jan. 24, 6 p.m.*

Royal Society of Health

LONDON
"Usk Dam and Water Undertaking," by T. Price. Guildhall, Swansea. Thurs., Jan. 24, 10 a.m.

Sheffield Metallurgical Association

SHEFFIELD
Annual General Meeting and Presidential Address by P. Jubb. B.I.S.R.A. Laboratories, Sheffield. Tues., Jan. 22, 7 p.m.

Society of Chemical Industry

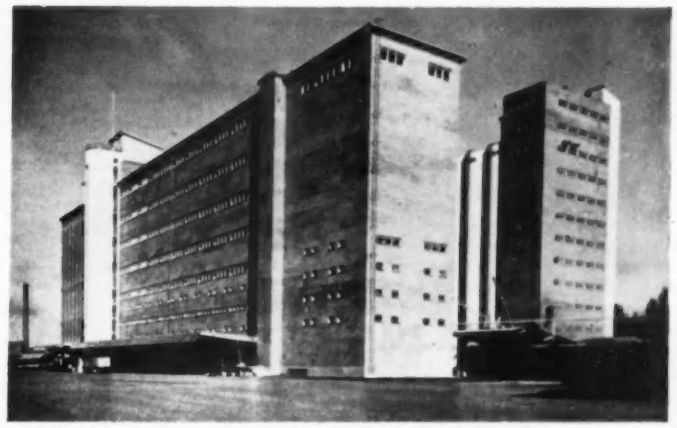
LONDON
Conversazione. Battersea Polytechnic, Battersea Park-road, S.W.11. Thurs., Jan. 24, 6.30 p.m.

Society of Instrument Technology

LLANDARCY
"Present and Future Trends in Electronic Instrumentation," by R. J. Redding. South Wales Section. Training Centre, National Oil Refineries, Ltd. Llandarcy. Wed., Jan. 23, 7 p.m.

EXPORTING A FACTORY

The new mill opened recently at Hameenlinna, about 80 miles north of Helsinki, Finland, is a good example of the way in which a British supplier of machinery and an overseas user can co-operate. The complete plant, which is for the cleaning, milling and packing of grain, was designed throughout by Thomas Robinson and Son, Limited, Railway Works, Rochdale, to meet the requirements of the Finnish Co-operative Wholesale Society (Osuustukkukauppa, Helsinki), and the British company supplied the whole of the equipment and superintended its erection on site. The buildings are of Finnish design, styled and proportioned in accordance with the well known modern tradition of that country, and based on a functional specification provided by Robinson engineers.



Designed by Finnish architects to a functional specification prepared by the British machinery manufacturers, the new flour mill at Hameenlinna, Finland, is an outstanding example of international co-operation.

The plant comprises cleaning, milling and packing departments, a warehouse, and grain and flour silos. Cleaning, milling, bulk storage and packing are carried out in the main 10 storey block; there is also a separate building for rye milling. A further block of buildings is provided for grain storage and preliminary cleaning. A provender mill is being erected on the same site, and it is intended that a bakery should be built there at a later date.

Grain can be received at the mill, and flour can be dispatched, by road or rail as required, and the pneumatic intake equipment is specially designed to enable it to deal with all types of transport vehicle, including 40 ft. long Russian boxcars, which deliver a large proportion of the mill's wheat supplies. The rail tracks separate the mill proper and the receiving plant and silos. There are 32 main circular storage bins of reinforced concrete; these, with 21 interspace bins, have a total storage capacity of 12,240 metric tons. A secondary intake plant also serves both road and rail vehicles. A 12 storey working building at the end of the rows of bins houses the elevators and preliminary cleaning equipment. The elevators and conveyors are so arranged that the contents of any bin can be re-treated, or be passed to a drying plant if required.

Extensive use is made of pneumatic conveying equipment, not only in the intake plant but also in the screen room and flour mill proper. Gravity flow is also used, and the spouting for the two different means of conveying is identified by being painted in two distinctive colours. Colour has, in fact, been used most effectively throughout the plant, not only as a means of identification, but also artistically. So used, it contributes largely to the clean and pleasant working conditions in all parts of the mill. Safety has also been a major consideration in the design of the plant. Such potentially dangerous places as the boots of elevators are protected by automatic units which cut out the driving motor in the event of slip between belt and pulley, thus eliminating the risk of fire due to friction. Interlocking is extensive, and overflow spouts are provided throughout the plant. There is no sprinkler system, as water can be more destructive than a fire; instead, there is an intricate network of highly sensitive fire alarms, backed by a 24 hour fire-fighting service.

SLIDE-RULE FOR HYDRAULIC CALCULATIONS

Hazen-Williams and Manning Formulae Incorporated

A slide-rule which should be of value to engineers engaged on hydraulic calculations has just been placed on the market. Known as the "Tarrant Hydraulic Slide-Rule," it should reduce the time taken for many determinations connected with the flow of water through pipes and circular sewers and in open channels.

One side of the rule is used for flow in pipes up to 100 in. in diameter running full. Scales are provided for flow, diameter of pipe, head lost and length of pipe, and when any three of these factors are known, the fourth can be found rapidly with the minimum of calculation. There is also a scale for determining the velocity of flow. By means of a set of proportional scales on the lower edge of the rule, the same information can be calculated for pipes and sewers running partly full and a scale is also provided for ordinary multiplication and division. The calculations on this side of the slide-rule are based on the Hazen-Williams formula for flow of water in pipes.

The other side of the rule is used for calculations of flow in open channels. The scales on this side are for velocity, hydraulic radius, slope of channel and Kutter's constant n. The hydraulic radius for channels bounded by straight lines can easily be determined directly; for half-round channels having a depth of flow up to half the diameter, the hydraulic radius and area of flow can be calculated by use of an additional set of scales. The Manning formula is used for calculations on this side of the rule.

On both sides of the slide-rule the scales are printed in black in English units with the equivalent metric units printed in red. Designed by Mr. J. Tarrant, A.M.I.C.E., A.M.I.Mech.E., it is obtainable from the Paterson Engineering Company, Limited, Windsor House, Kingsway, London, W.C.2.

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Discussions at the fifth "Residential Course for Managers in Industry" of the University of Cambridge, which is to be held at Madingley Hall, near Cambridge, from July 1 to 27 next, will be mainly concentrated upon management and the changing structure of the national economy, human problems, and Britain's international position. The course is being organised by the University's Board of Extra-Mural Studies and further information is obtainable from the secretary, Stuart House, Cambridge. The fee is £110, including tuition, board, residence, and gratuities.

THE HUMAN ELEMENT

Inter-union leap-frog—Unfair to medicos—Rich men's money—Efficiency in the grocery stores—Changing picture of working population—Rights of the (wealthy) individual.

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A.S.L.E.F. Hedges at 3 per cent.

The decision of A.S.L.E.F. to accept the 3 per cent. wages increase offered by the British Transport Commission creates an intriguing position in the power politics of the trade union world. The union has been careful to say on acceptance that it will present a new claim at any time in the future if the circumstances seem to justify it. Its eyes are clearly on the N.U.R.

The N.U.R. has had a similar offer made by the Commission but has decided for the moment to press on with a 10 per cent. claim. Its eyes are clearly on A.S.L.E.F. Both are well set for a game of leap-frog in which inter-union jealousy is the driving force. At the moment the N.U.R. can say that it better represents the interests of railwaymen because it is holding out for a larger wage increase then the rival union has accepted—though its position is not so far committed that it cannot decide that discretion is the better part of valour if it finds that settlement for less than 10 per cent. suits its book better in due course. A.S.L.E.F. can say that it has got a quick rise for its members, has shown a degree of responsibility in its attitude (after all, it was A.S.L.E.F. that organised the strike of footplate men in 1955 out of which the N.U.R. won a novel reputation for a brief time as the organisation of moderation and sweet reasonableness) and it can also say to its members that the door has been left open for a further demand if the N.U.R. wins a better decision and thereby does some of A.S.L.E.F.'s work for it.

It would be encouraging for the general public, and for the B.T.C., if some end could be seen to this inter-union bickering. Whoever is gaining from this Lilliputian political set-up it is certainly not the railways or the public. It is not the union members either in the long run.

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Doctors in the Doldrums

There is plenty of food for thought for the cynical, especially if they are professional men, in the current negotiations of the doctors with the Government on pay increases. The main argument centres on the Government's insistence that there is no contractual obligation (the doctors say there is) to raise capitation fees in accordance with the cost of living. The doctors put their case on the moral argument rather than on the legal one. There is substance in their claims, though everyone could argue for long enough about the base period from which the change is to be calculated.

Beyond the immediate argument, however, lies a point of greater substance. The Government is clearly as determined to be tough with a professional body as it is weak against trade union pressure. The doctor's case is strong enough to have caused a national outcry if the Government had tried the tough line with a union. Doctors and other professional people are in a difficult position when it comes to strike action. It is not in the professional tradition and it generates little immediate pressure on the Government. The doctors' dilemma is a warning to any other profession which would care to stake its fortunes on a marriage of convenience with the State.

The Government's insistence that it has not turned down the claim, but only postponed favourable consideration because the country cannot afford to pay more, is bureaucratic humbug. It ceases to be such only if the argument is used against the railway unions and similar organisations as well. It is, of course, a useful formula. The Government cannot pay more at a time of inflation because £20 million a year more would stimulate inflation: it cannot pay more in a time of deflation because it must then cut its expenditure. This is a touching but quite unconvincing regard for the taxpayer's money.

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Savings Habits of the Wealthy

Once upon a time it was easy to define what constituted a rich man. He was above all a man of property, defined either in terms of heads of cattle or negotiable securities. To-day matters are rather different. The well-paid business executive with large and secure pension rights and without a capital asset to his name might rank as the wealthier of the two. Custom dies hard, however, and the rich are still thought of as men of property. Since they command large resources and buy and sell different forms of investments on a large scale (ironically, especially on their death-beds) their investment habits are still of wide interest from a national point of view.

The Oxford University Institute of Statistics has carried out a survey into the finances and saving habits of the upper middle classes. The sample contained doctors and accountants as well as directors and a selection from Debrett. The professions were thus represented to some extent. The survey revealed a surprisingly small proportion of people (44 per cent.) who wanted capital appreciation. Nevertheless, the majority looked for some sort of insurance against the effects of inflation on the real value of the assets. Most people did not use capital gains for living expenses but re-invested them in some form. Marketable securities represented as much as 42 per cent. of property. As many as 75 per cent. paid insurance premiums on life policies but there was no great interest in assurance as a form of newly created savings. This is hardly surprising, since the main attraction of such policies is the capital sum or its corresponding annuities. Likewise, there was little interest in such things as savings certificates. On the whole the picture emerges of the wealthy seeking high yielding investments but of a not very active process of buying and selling in order to get it.

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Management Course for Retailers

Inefficiency in retail distribution is a major source of waste, of labour particularly. It is also an important factor in high retail prices, and therefore in the cost of living, which is reflected in the wages that manufacturing industry has to pay. There has in recent years been a growing realisation that much of the waste could be eliminated by the adoption of more efficient shop lay-outs, and by the application of modern management techniques.

Urwick, Orr and Partners, Limited, a leading firm of management consultants, announced last week that they would hold at their training centre in Slough one-week courses for senior executives of multiple grocery firms. The new course, entitled "Management and Profitability in the Multiple Grocery Field," will be residential (fees 50 guineas inclusive). It is designed as "an intensive appreciation of the management techniques and methods" which, Urwicks say, can make an important contribution towards reducing costs, increasing margins and thus improving net profitability.

The syllabus includes management organisation and staff control, costing systems and cost analysis, stock control, incentives, work and method study, handling and movement of goods, shop and warehouse lay-out and training of managers and supervisory staff. The question of equipment is not mentioned but will presumably be dealt with under various headings. There is in this field a tremendous opportunity, not only in grocery multiples but in the whole of retailing e.g., in the retailing of radio and television sets and household appliances of all kinds. It is a matter to which a large number of companies in the engineering industry cannot afford to be indifferent.

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Twenty Years After

Figures published from the 1951 population census show some major changes in the distribution of the working population since 1931. In these changes it would appear that one way and another engineering has played an important part.

One of the biggest changes over the two decades has been the number of married women in employment. They increased from under a million to almost two and a half million. One of the key industries to shed labour was agriculture, and since the 1951 census was taken it will have been joined by textiles. The major-growth industry has obviously been engineering, with which may be coupled metals. Over the 20 years, numbers employed in these two groups went up from 1,557,000 to 2,260,000.

Among the smaller groups there were significant advances in the armed forces and the professions. The former is the product of national service. In the case of the latter, engineers may have played a significant part. The growth of the profession and the industry is gratifying but leaves no room for complacency. In a world where the pace of industrialisation continues to gather momentum, the important comparison is not with our own past but with the rate of change in other highly industrialised countries. There, as is well known, the picture is as yet far from reassuring.

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Farmer Glanfield Victorious

The Surrey farmer who grabbed the axe from the hands of the woodman sent by the Southern Electricity Board to cut down his trees to make way for a power line appears to have won his case. Faced with such intense personal opposition—he left his gun in his car to avoid the temptation of using it!—the Board have not insisted on their legal rights and the line will now skirt Mr. Glanfield's land, not go through it. Except for four in a hedge, his cherished trees will stand to greet the coming generations. The timber and the damage to amenities will be valued and compensation paid and, one assumes, the Twelve Oak Farm will remain identifiable according to its name.

The under-dog is popular the world over, and particularly in Britain (provided he is strong enough to be noticed) and Farmer Glanfield did not lack for supporters. It is good that it should be so even if, at times, the privileges or property rights of a few are allowed to stand in the way of community interests. The art of local government—which after all is there to serve local people in the way they want to be served—is to find a happy medium where a fair bargain can be struck between the rights of the one and the interests of the others. The weakness of this, as indeed of all decisions taken by the vote or by people elected to act on the voters' behalf, is that the majority rules. Majorities have a notorious disregard for the rights of individuals who do not conform—in our country perhaps less than in most others.

When, as in this case, the individual's wish can only be granted at the cost of others it can be argued that some machinery should be in existence to listen to both sides and decide on a fair settlement. But who is to measure the psychological aspect of the loss of oak trees? Who is to say there are no alternatives to a given course without costly research? It is perhaps as well that from time to time authority should be seen in retreat against the individual's rights. Certainly authority should have the onus of proof of its case placed upon it. There is still hope for the individual in the atomic age if the sentiment in the popular song "Woodman Spare that Tree" can be enshrined in a political principle. On the other hand, perhaps Mr. Glanfield has ideas of his own about the future of the land where the oaks stand.